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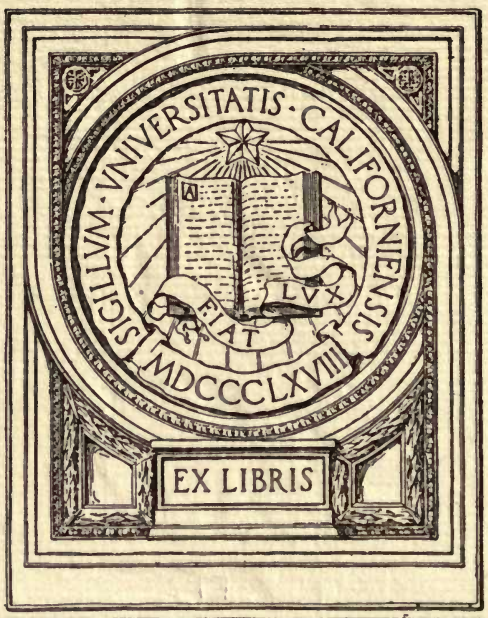
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CHAPTER I

WORKING DRAWINGS*

A working drawing should convey to the eye of the observer a clear idea of what the draftsman or designer wants made, and of how the various details are to be carried out. The drawing should be so complete that when it is passed into the shop no further questions will be necessary, and to this end, all necessary information as to material, bolts and screws, the kind of fits and finish desired, etc., should be plainly marked on the drawing.

It is not the business of the mechanical draftsman, however, to make pictures, and he seldom has occasion to draw perspective views. He has to convey his ideas by simpler methods than this, and in making working drawings uses what is called "Orthographic Projection," or simply, projection. His drawing may not always look like the object, from the pictorial standpoint, since certain conventional figures and methods are adopted to represent machine parts, which can be drawn much quicker in this way than if their true form were reproduced. Thus, it is not customary to draw screw threads in the way in which they actually appear to the eye; an easier and quicker method of representing them is adopted, and the same is true of other parts.

To read working drawings, or to be able to make them, one must not only be familiar with the conventional methods commonly used, but one must understand wherein they differ in principle from perspective drawings or photographs, which represent the object as it appears to the eye.

To a novice a working drawing looks like a lot of lines that do not represent clearly what they are intended to show; but an experienced mechanic or draftsman finds that his attention is not taken by the mere lines, and that he involuntarily thinks of the objects which they stand for.

Projection Drawing

Briefly stated, when a drawing is made by projection, it represents an object as one would see it if the eye could be directly over each point of the object at the same time; or, what would be the same thing, if one could stand at an infinite distance from the object and still observe it.

By a very simple illustration the reader will be able to understand the meaning of this definition and will see what is the difference between a view in perspective, such as one sees in a picture, and a view in projection, such as one finds in a working drawing.

Place a box, with the cover removed, on its side, and then look at it with your eyes right in front of the open side; or if preferred, place a

* MACHINERY, October and November, 1901.

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camera in this position and photograph the box. The result will be a view, Fig. 1, where not only the front edge of the box appears, but the interior sides and bottom as well, indicated by the lines *ABCD*. The reason for this is that the lines of sight diverging from the eye of the observer reach both the front edge of the box, as indicated at *A* and *B* in Fig. 2, and the bottom, indicated at *C* and *D*. This is a view in perspective and from it one gets a partial idea, at least, of the shape and depth of the box, besides the shape of the front edge.

In Fig. 3 is the same view of the box, but shown in projection. Here there is nothing to indicate what the depth of the box is. The view gives a conception of the shape of the front, but to form an idea of its depth there must be another view taken at right angles to the front view.

In Fig. 4 is shown how this view in projection may be supposed

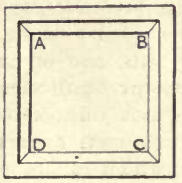


FIG. 1

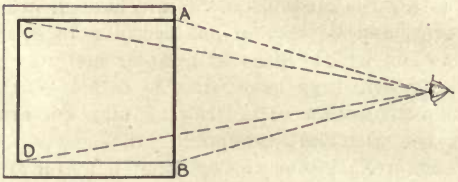


FIG. 2

FIG. 3

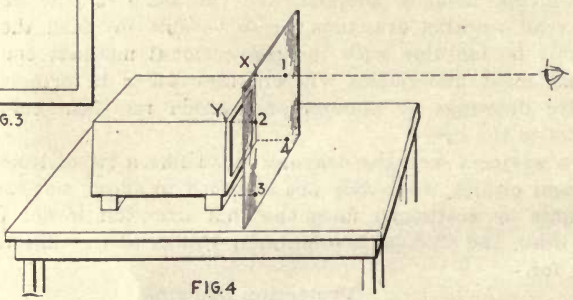


FIG. 4

Figs. 1 to 4. Views in Perspective and in Orthographic Projection

to be produced. The box is placed on the table, and in front of it, and parallel with it, a piece of glass. Let a person stand so that his eye will come directly in line with one corner *X* of the box, as in the illustration, and make a dot on the surface of the glass, indicated by point 1, where the line of vision passes through the glass to this corner. Now let him move until his eye comes exactly in front of point *Y*, and mark point 2 on the glass, and so on, all the way around. Then, by connecting points 1, 2, 3 and 4 he will have a correct representation in projection of one edge of the front of the box.

The lesson taught by this is that a projection drawing gives no idea of distance to or from the observer in a single view, but represents, simply the distance in any direction in a plane surface like a

sheet of drawing paper, held squarely in front of the observer. This is why more than one view is required to show in projection what may be evident in a single view of perspective. Also, in projection, the views, generally being taken at right angles, represent the sizes of machine parts accurately, while, in perspective, part or all of them may be foreshortened, making it difficult to properly dimension them.

Arrangement of Views

In Fig. 5 are four views of a wedge-shaped block in the top of which is driven a round pin. All these views of so simple an object are, of course, unnecessary, and they are merely shown in order to indicate the correct positions of the different lines in the several views. The front view appears as though the object were held directly in front of the observer. The top view is placed above the front and appears as though the observer were looking down upon the object. The end view at the right shows the block as it would appear if looked at from

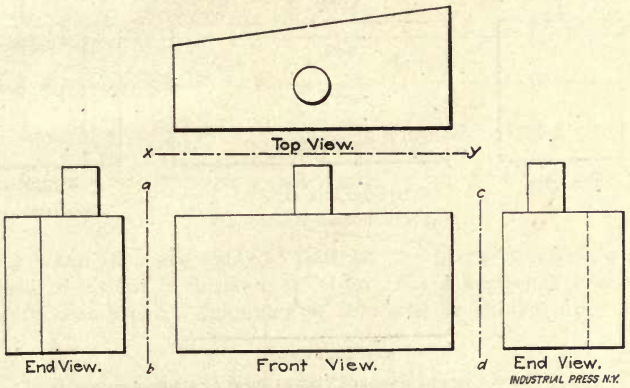


Fig. 5. Arrangement of Views—Third Angle Projection

the right-hand end, and the end view at the left shows it as it would appear if looked at from the left.

The views, arranged as here shown, are in what is known as the "third angle of projection," the full meaning of which cannot be explained without taking up the elementary principles of projection, a treatment of which is to be found in any book on mechanical drawing. This is the arrangement commonly adopted for machine drawings.

In Fig. 6 is an arrangement of views of the same object in what is known as the "first angle of projection." This arrangement is generally employed in architectural and in structural work, such as drawings of bridges, etc., but is not so often used for machine drawings. It will be noted that in Fig. 6 the top view is below the front view, the view of the right-hand end of the block is shown at the left, and the view of the left-hand end is shown at the right. Comparing further, it will be seen that in Fig. 5 the pin in the front view points toward the top view, while in Fig. 6 it points away from it; and in the end views, the pin appears near the inside edges in Fig. 5, and near

the outside edges in Fig. 6. The views are so arranged in Fig. 5 that if the top view be placed directly on top of the block and then the sheet of paper be folded over on the line *x y*, the front view will come directly in front of the block; and then if the sheet be again folded or bent back along *a b*, the left-hand end view will come in front of the left end of the block; and finally, if it be folded back along *c d*, the right-hand end view will come in front of the right-hand end of the block. If the block were inclosed in a box having transparent sides and the outlines of the block were traced on each of the sides as they appeared to an observer looking through the successive sides of the box, and finally the sides were unfolded so as to lie flat in one plane, the views would appear as in Fig. 5.

To produce the arrangement shown in Fig. 6 we may assume the block to rest on the paper with its top side uppermost. If we then

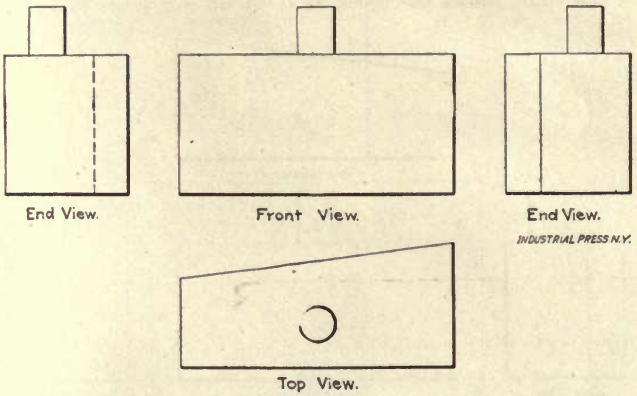


Fig. 6. Arrangement of Views—First Angle Projection

mark around the block with a pencil we will get the top view shown. If the block then be tipped over with its front side uppermost and we mark around it, the front view will be obtained. Again, if it be tipped first on one end and then on the other the two end views will be obtained.

A close study of Figs. 5 and 6 will show how necessary it is to adopt some one system and to adhere to it, as otherwise there will very likely be much confusion in the shop, and perhaps mistakes made by the patternmaker.

Conventional Lines

The various styles of lines used in working drawings are shown in Fig. 7. The ordinary line (1) is for outlining objects, for section lining, and for all ordinary purposes. The shade line (2) is used to represent the edges supposed to separate the light from the dark surfaces of an object—that is, the surfaces on which the light strikes from those in shadow, as shortly to be explained. The dotted line (3) is chiefly for representing the details of an object when they are so covered as to be obscured from view. Many details can be represented

in this way and their arrangement clearly indicated, although they would not be visible in the actual piece. The dash line (4) is used mainly for dimension lines. The dash and dot line (5) and the dash and double dot line (6) are both used for center lines, some draftsmen preferring one and some the other. When a drawing of a piece, like a wheel or a bolt, for example, is symmetrical, a center line is sometimes drawn through the center or axis of symmetry of the figure, and if there are two views of the same piece, the line is frequently extended through both, showing that they are connected. The dash and dot line (5) is also used for connecting lines between different views, as in Fig. 8, and for construction lines in laying out mechanical movements or geometrical figures. In no case are the lines (5) and (6) used to represent the actual edges or surfaces of a piece, except occa-

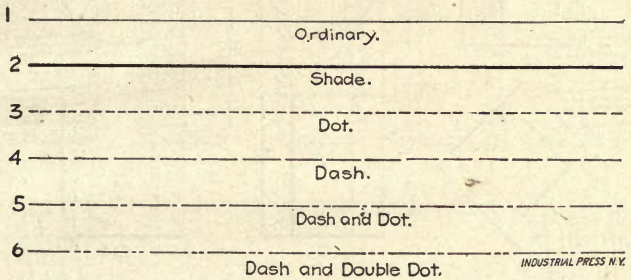


Fig. 7. Conventional Lines

sionally when they are made to indicate the plane in which a piece is supposed to be cut or broken, in order that a sectional view may be shown in that plane. Examples of this will be shown later.

Shade Lines

In architectural drawing the effect is improved by taking account of the shadows that would be cast by the sun were it shining upon the object. The rays of the sun are supposed to come from above and from the left at such an angle that when projected on the paper they would be represented by lines making an angle of 45 degrees with the horizontal and vertical. A great deal of time is sometimes spent in determining which surfaces should be light, which in shadow, and what the shape would be of the shadows cast.

In mechanical drawing attention is sometimes paid to this point to a limited extent. Assuming the sheet to be held directly in front of the observer, and the light to come from over his shoulder in the direction of the diagonal of a cube, heavy lines would be drawn along the edges separating the light from the dark surfaces. In many cases it would require considerable study to determine what lines should be a limited extent. Assuming the sheet to be held directly in front of cases, however, it is the lower and right-hand lines that must be shaded, and the best practice is to follow this general rule without regard to the exact manner in which the light strikes. When the lines are used in this way they answer the purpose of improving the appear-

ance of the drawing, and they also indicate which are the raised and which the depressed surfaces. This will be clear from Fig. 8, in which several examples of shading are shown. At *A* is a square block, nollow in the center. The outer shade lines show that the block is raised above the surface of the paper, and the location of the inner lines shows that the center of the block is depressed below the outer surface of the latter. At *B* is shown how the block would be shaded if at an angle of 45 degrees. Since the projection of a ray of light is supposed to be at 45 degrees there is no logical reason why the lines *c c* should

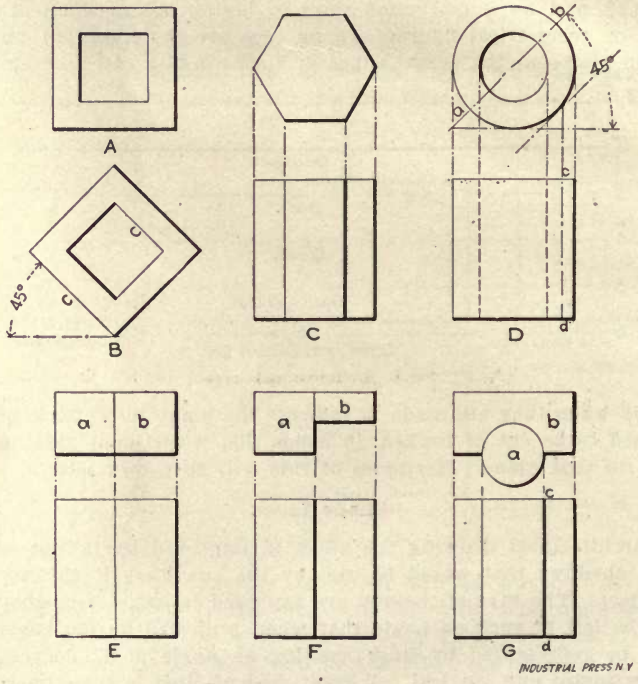


Fig. 8. Shade Lines

not be shaded instead of those shown; but the figure looks well as drawn. At *C* is the shading for a hexagonal prism, and at *D* for a hollow cylinder. The shading on the top view of *D* starts at the 45-degree line *a b*, gradually increases, and then diminishes to nothing when it again reaches the line. The right-hand element of the cylinder in the lower view of *D* should not rightly be shaded, because it really separates two dark surfaces, the shadow actually starting on the element *c d*. In practice, however, the right-hand element is the one shaded. At *E* are two blocks *a* and *b* of the same size. No shade would be used to separate them; but at *F*, where blocks at *a* and *b* are of different thicknesses, the shade line would be necessary. At *G*

the block *b* is recessed for the cylinder *a*. It may be shaded as shown, although some draftsmen might prefer to leave off the shade line *c d* in the lower view.

Screw Threads

Conventional methods of representing screw threads are shown in Fig. 9. These are the most common methods, although there are some others less frequently met with. Methods *A* and *B* are generally employed, and of the two that of *B* is to be preferred, as it is more easily done. Some draftsmen place the heavy lines shown at *B*, repre-

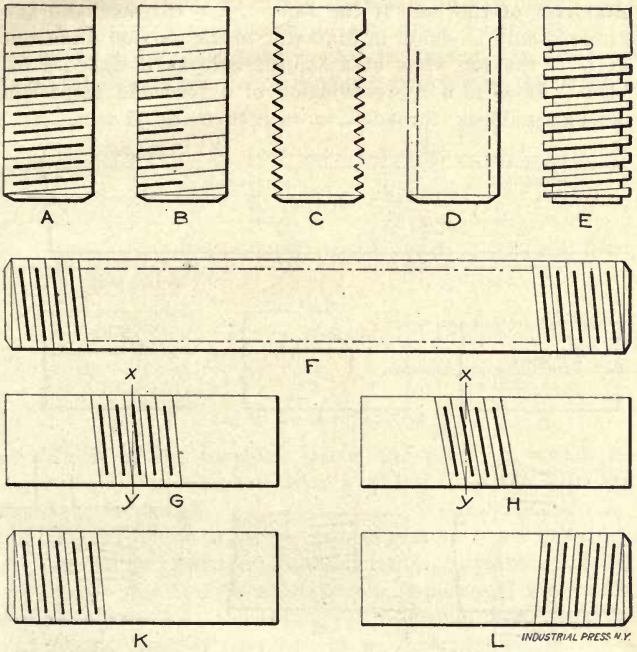


Fig. 9. Conventional Indications of Screw Threads

senting the bottoms of the threads, on the right-hand side instead of on the left-hand side, as it then gives the effect of shading. At *E* is a conventional square thread. If any long piece is to be threaded the entire length, the threading can be indicated as at *F*, which saves drawing the complete thread. The difference between the representation of a single and a double thread is indicated at *G* and *H*. The single thread is at *G*, and the inclination of the lines is such that the line *x y*, at right angles to the axis of the piece, passes through the top of the thread at one side and the bottom of the thread on the other side of the bolt. At *H* the inclination is such that the line *x y* passes through the tops of the threads on both sides of the bolt. At *K* is shown a right-hand thread, and at *L* a left-hand thread.

Tapped Holes

At *A B C D*, Fig. 10, are methods of representing tapped holes where they are obscured from view and must be shown by dotted lines. Those at *A* and *B* are much used, but where the drawing is crowded, those at *C* and *D* are to be preferred, and in any case they make a neater appearance. Top views of surfaces having tapped holes may be indicated either as at *E* or *F*. If as at *E*, a circle should be drawn of a diameter equal to the outside diameter of the bolt, and the hole marked as indicated, which shows that the hole is to be tapped and also indicates the size of the bolt to be used. If the method at *F* is employed, the inner circle should be approximately equal in diameter to the diameter of the bolt at the base of the threads, and the outer dotted circle should be equal in diameter to the outside diameter of the bolt. At *G* is the top view of a tapped hole as it appears in a sectional view. At *H* is a representation of a threaded piece which extends through a block threaded to receive it, as shown. At *K* is a

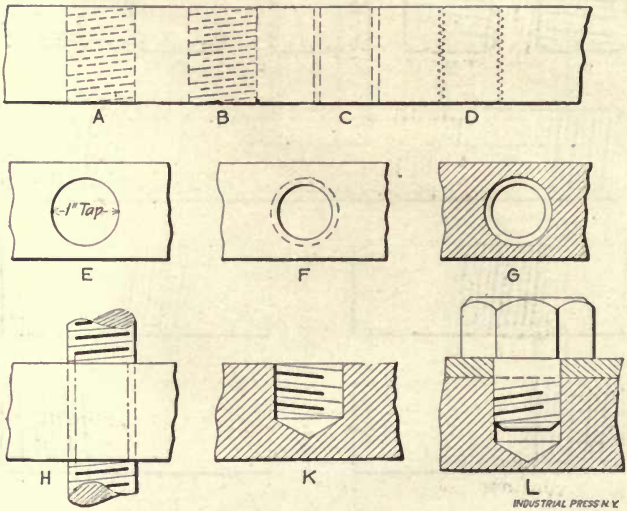


Fig. 10. Representation of Tapped Holes

vertical section through a tapped hole. This is for a right-hand thread, although the lines incline as though it were a left-hand thread. This is simply because only that part of the thread is visible which is at the farthest side of the hole where the threads must, of course, incline in a direction opposite to the direction they take at the front side of the hole. This can be clearly seen by examining a bolt or nut. At *L* is shown a section through a tapped hole into which a bolt has been screwed.

Broken Sections

In Fig. 11 are shown methods of representing bars and rods, shafting, structural beams, etc., when it is not convenient to show their whole length on the drawing. In such cases these pieces would be

drawn as long as the limits of the drawing would allow, and then would be broken as indicated, to show that the full length of the piece is not represented. In placing the dimensions on the drawing the full length would, of course, be given.

General Principles of Working Drawings

When a draftsman has to make a drawing of a machine already constructed he first measures and sketches each part separately, putting all necessary dimensions upon the sketches, and then he assembles these parts, so to speak, in the form of a general drawing. On the other hand, if he has to design a machine he will first make a general drawing with the parts in place and from this he will obtain the dimensions of the various pieces which he will draw separately, or at least in sufficient detail to show clearly what is wanted. In either case, he must have either a general or assembled drawing of the machine, and

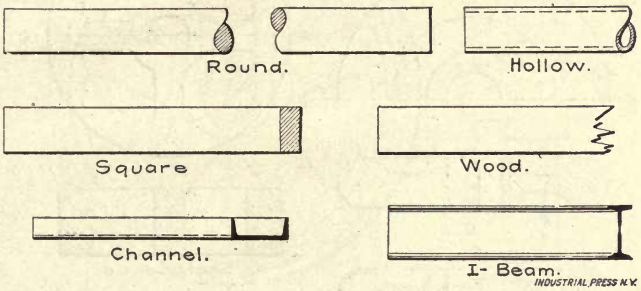


Fig. 11. Broken Sections

detail drawings of the machine parts, the order in which they are made depending upon whether he is working from the machine itself, or originating the design.

In the general views outlines are drawn of such details as are thought essential to clearness; but as certain features of construction and many of the small parts of the mechanism would inevitably be invisible to one looking at the assembled machine, they must be represented by dotted lines if they are to be incorporated in the general view. A multiplicity of these lines leads to confusion, however, particularly if it is attempted to dimension them, and for this reason the detail sheets are necessary.

We thus see that obscure details, not visible when looking at the assembled piece, may be represented either by the use of dotted lines or by making separate views of each piece apart from its relation to the others.

Sectional Views

A third method of representing details is by means of sectional views. Suppose, for example, a drawing were to be made of a connecting-rod end, in which were the brasses, the adjusting wedge and screws, etc. A general view of the rod might be made, with part or all of the details shown by dotted lines; and then, on another sheet,

or on another part of the same sheet, the details could be drawn separately and properly dimensioned. That would be one way to make the drawings. Another way would be to make a general view of the rod as before, but to show the end as though it had been cut or sliced in a plane parallel with the paper, and the upper parts removed, exposing the details. The parts cut through would be "cross-sectioned," bringing them into bold contrast, and the dimensions could all be placed on this one drawing. Such a method is possible with a simple construction, having but few parts, and is often adopted to advantage.

Sectional views may also be used for much simpler purposes than above outlined. They may be used to show the shape of the arm of a

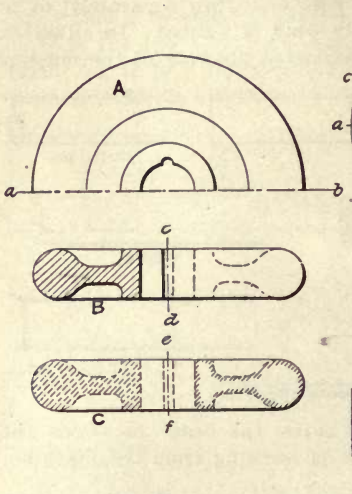


Fig. 12.

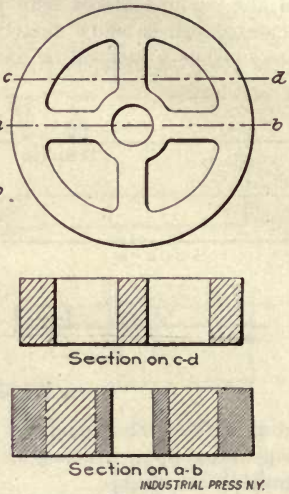


Fig. 13.

Methods of Showing Sections

pulley or of any other part of any casting that can be conveniently represented in this way. The cutting plane may be assumed to lie at any angle necessary to bring out the details most clearly; or, if desired, a sectional view may represent a casting as though it were cut through a part of the distance on one plane, and the rest of the way on another plane, either higher or lower, as convenient. All that is necessary to have the view clearly understood is to draw a line through one of the views of the piece, indicating just where the sectional view is supposed to be taken, and then to make a note on the drawing to that effect.

In Fig. 12, at *A*, is a plan view of a hand-wheel. As the wheel is symmetrical, it is quite unnecessary to draw more than half the wheel, although the whole wheel may be drawn if desired. It is here represented as though cut in two along its diameter on the line *a b*. This line should be a dash-and-dot line, as shown, and not a solid one. It has been pointed out on page 7 that one of the uses of a dash-and-

dot line is as a center line where a piece is symmetrical, and its use here would indicate that the half of the wheel not drawn was like the part that was drawn, even if it were not otherwise apparent; for under no other condition would the figure be symmetrical.

At *B* and *C* in Fig. 12 are shown sectional and edge views of the hand-wheel and the different ways in which they may be represented, according to the fancy of the draftsman. In *B*, to the right of the center line *c d*, is an edge view of the wheel in which the shapes of the rim and hub are shown by dotted lines, since they would not be

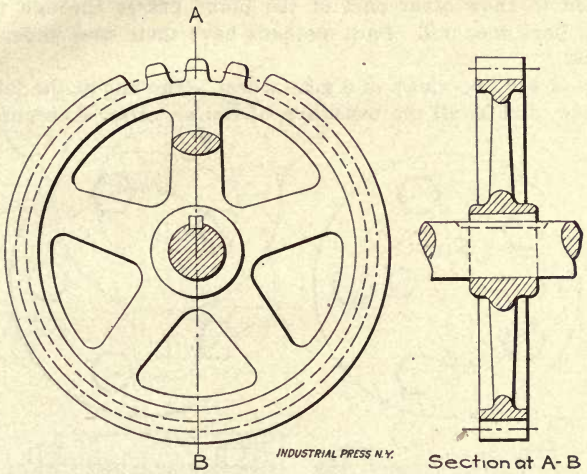


Fig. 14. Conventional Sectioning of Gear Wheels

visible to an observer who held the wheel so that he looked directly at the edge or rim. To the left of *c d* is a sectional view taken along the line *a b* in *A*.

In the view below this, at *C*, are shown two methods of drawing what are termed "dotted sections." The sections are supposed to be taken on the line *a b* as before, but cross-sectioning is done by dotted lines, indicating that the shape of the section would be as shown, but that the parts in front of it have not actually been cut away. This is a very convenient convention to adopt at times. For example, in showing a milling machine knee and saddle it would enable one to represent the knee and saddle as they actually appeared, and also to show a sectional view of the mechanism under the saddle and inside the knee. If, on the other hand, the view were drawn as though the knee were actually cut through, one would not form an idea of its exterior appearance unless another view were drawn. It will be noted in the figure that the dotted lines extend clear across the section, as drawn at the left of *e f*, and only along the edge of the section at the right of *c f*.

In Fig. 13 is a pump valve-seat having four webs connecting the outer rim with the hub. There are two ways of showing a sectional

view of a piece in which webs occur. If the view were taken along the center line *a b* and sectioned, as usual, nothing would be gained, since it would give no idea of the shape of the webs. Some, therefore, prefer to take the section to one side of the web, as on the line *c d*, and as shown in the upper sectional view. This indicates clearly what the shape of the web is. Others, however, prefer to adopt the expedient illustrated in the lower sectional view. Here the section is supposed to be taken along the line *a b*, but where the plane cuts through the webs, the sectioning or hatching is done with the lines further apart than in the balance of the section, thus making enough distinction to show what part of the plane passes through the webs and what part does not. Both methods have their uses under suitable conditions.

In Fig. 14 are two views of a gear wheel. The one at the left side is a side view, and as all the teeth are, of course, alike, it is unnecessary

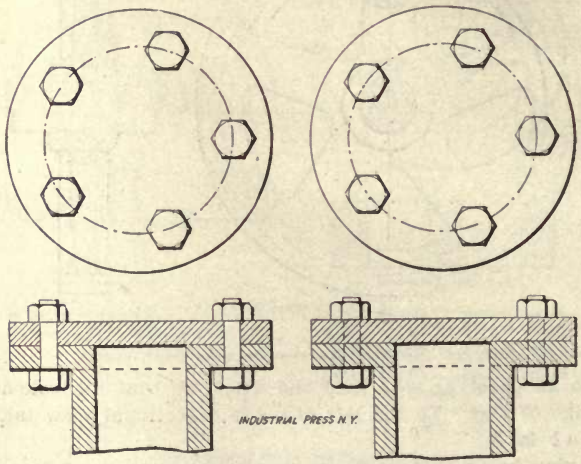


Fig. 15. Representation of Bolts in Sections

to draw more than a few of them. The pitch line of the teeth is represented by a dash-and-dot line, this convention always being followed. In the part of the rim where the teeth are not drawn, the face of the gear is indicated by a solid line, and the position of the roots of the teeth by a dotted line. Some, however, prefer slightly different conventions. To show the shape to which the arms are to be formed, a sectional view of one of the arms is drawn in this view. The end of the shaft is supposed to be broken off and is sectioned.

The right-hand view, in Fig. 14, is a sectional view taken along the line *A B*. It will be noted that the shaft and key are not sectioned. The method followed in such cases is usually to section the castings or inclosing parts, such, for example, as the hubs, rims, etc., of a wheel, but not inclosed parts like shafts, rods, bolts, keys etc. A bushing being both an inclosed and inclosing part might or might not be sectioned, individual judgment dictating the method here as

elsewhere. This gear has five arms, and the line *A B* cuts through one of them only. They are not sectioned in the right-hand view, and two opposite arms are drawn as though both of them lay in the plane of the paper. While this is not correct, it is the method usually followed. The method of representing the gear teeth in sectional views is generally as shown in this cut.

In Fig. 15 are sectional and top views of a cylinder or pipe on which a blank flange is bolted. There are five bolts, and the plane in which the sections are taken would cut through only one of them. Most draftsmen, however, would draw the sectional view as indicated at the left. The bolts are shown as though both were in the plane of

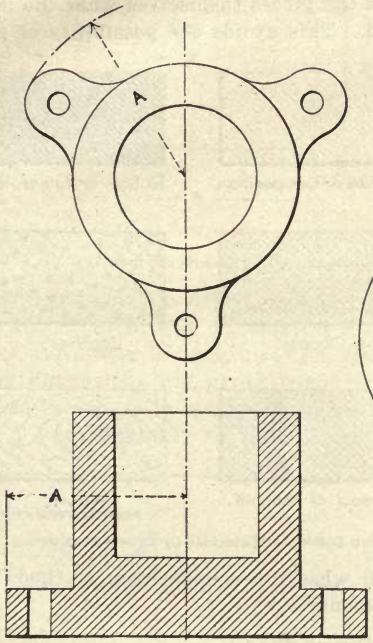


Fig. 16. Section of Unsymmetrical Object

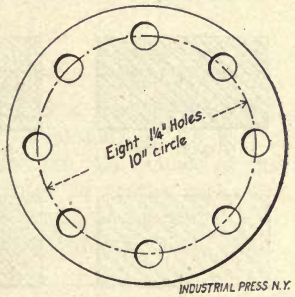


Fig. 17. Dimensions of Holes in a Circle

the section, and these bolts are not sectioned, but are drawn in full, as explained above. It is not necessary, moreover, to show more than two of the bolts, since it would detract from the clearness, and the top view shows plainly how many bolts there are. Some draftsmen think bolts drawn in this way are too prominent, and prefer to represent them in sectional views as shown at the right in Fig. 15. This method also has the sanction of fairly common usage.

Fig. 16 is another example of a figure that is not symmetrical in all respects. It shows two views of a step bearing having three ears or lugs for bolting it to its base plate. In making a sectional view of such a piece should the cutting plane be supposed to pass through the lugs? In most cases, yes, and according to common practice the

sectional view would be made symmetrical, and the distance *A* in the lower view, from the center of the piece to the outer end of each lug, would be made equal to the distance *A* in the upper view.

In any machine various kinds of metal and other material are used, and when sectional views are made it is convenient to have some standard method of cross-sectioning the different parts to indicate what the metal or material is. Conventional sectionings adopted for this purpose are given in Fig. 18, the system here represented following very closely that used by the U. S. Navy Department. It should be said, however, that draftsmen are coming more and more to section all parts alike, adopting the style used for cast iron for all kinds of material, and then printing on the pieces themselves what the material is of which they are composed. This avoids the possibility of mistake

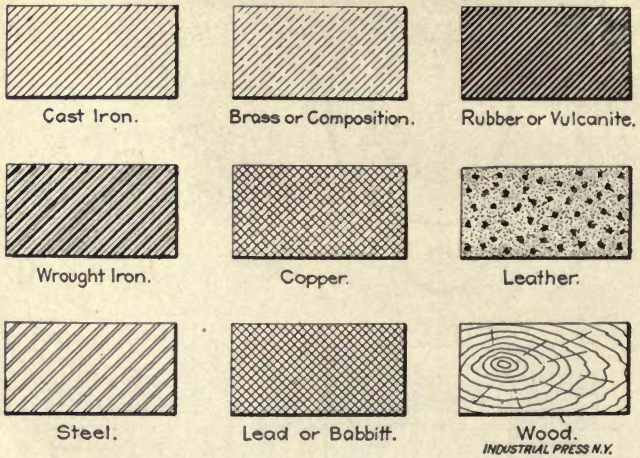


Fig. 18. System of Indicating Different Materials by Cross-sectioning

through failure to understand what the conventional methods of sectioning are supposed to represent.

Dimensions

The most important part of a drawing is the dimensions. They should be given so fully and completely that a workman will never have occasion to measure a drawing. The dimensions should include an "over-all" measurement and the different measurements that make up the "over-all" size. Dimension lines, and the extension lines which the arrow heads of the dimension lines touch, are usually fine black lines made up of long dashes. They should be so drawn as to appear secondary in importance to the drawing itself. Some draftsmen draw all these lines in red ink and use a solid instead of a broken line. In a blue-print the red lines will appear lighter than the black ones, making a good distinction.

In Fig. 19 is a sketch of a bushing. The diameter of the bore is given at *H* by a dimension passing through the center of the circle.

It is somewhat confusing, however, to have more than one dimension line passing through a center and therefore it is better to give the other diameters elsewhere, if possible, as at *E*, *F*, and *G*. The length of the various steps of the bushing are given at *A*, *B*, and *C*, and it will be noticed that they are slightly offset—that is, the dimension lines do not extend in one straight line. This makes a very clear arrangement. The over-all dimension is at *D*. Methods of placing dimen-

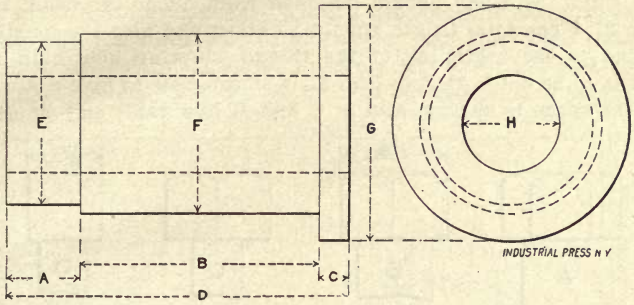


Fig. 19. Sample Drawing, Showing Location of Dimension Lines

sions on holes that are drilled in a circle or a row are shown in Figs. 17 and 20. That in Fig. 17 requires no explanation. In Fig. 20 center lines are drawn in each direction through the centers of the holes and the dimensions are given from center to center each way, and also from the edges by which the holes are to be located.

Fig. 21 refers mainly to the dimensions of the bolts. At *A* is a

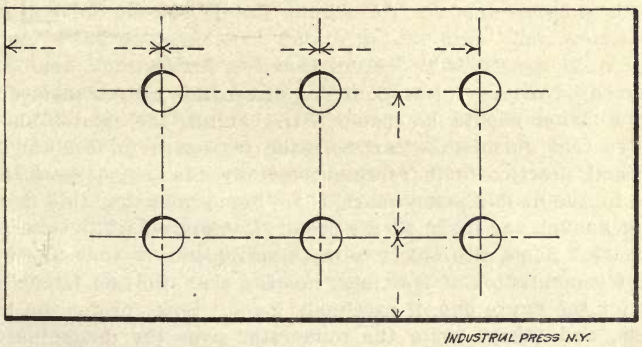


Fig. 20. Dimensions of Holes Located in Straight Lines

hexagon head bolt, so drawn that three sides of the head are visible. Bolts are usually drawn in this way because they look well, and as most bolts used in machinery are standard and taken from stock, no dimensions are necessary other than to specify the diameters and lengths. These may be printed on the drawing, or better yet on a list of bolts and other small parts, sometimes called an order list, which should accompany the drawings. Every bolt and machine screw

should be specified in some such way. At *B* is a hexagon head bolt, so drawn that only two sides are visible. If it is a special bolt it should be represented like this so that the dimension across flats can be given, to which the head is to be milled. At *C* and *D* are two ways of drawing a square head bolt, according to whether the dimensions across flats are necessary or not. In cases like *B* and *D* the abbreviations *Hex.* and *Sq.* should be used as shown, so that there will be no mistake about the style of head desired.

The length of a bolt should be given from under the head, as at *E* in Fig. 21. The total length should be given and also the length from the head to the beginning of the thread, showing how high up the thread is to be cut. At *F* in Fig. 21 is shown how to give a dimension when the space is narrow, and at *G* and *H* how radii may be denoted.

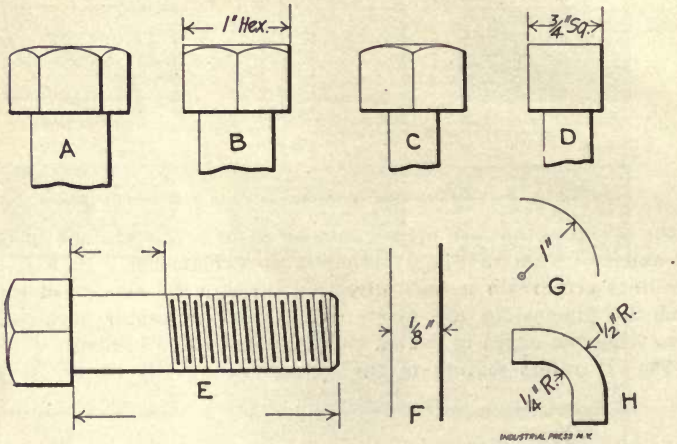


Fig 21. Dimensions of Minor Details

There are various rules about the dimension figures themselves, to which allusion should be made. First of all, the figures should be plain, so that no mistake can be made in regard to feet and inches. The usual practice is to represent feet by the prime mark (′) and inches by the double prime mark (″). Some hold that this is not distinction enough and insist on the use of "ft." for feet while retaining the inch mark. Some also object to the slanting line between the numerator and denominator of fractions, holding that the line might be mistaken for the figure one, if carelessly made. Some prefer the horizontal line, and others write the numerator over the denominator and omit the separating line entirely. It is customary to arrange all the dimensions to read either from the bottom or the right-hand side of the drawing, though it is possible to have everything read from the bottom by making the figures upright, or up and down on the sheet, regardless of the direction of the dimension lines. In the shop, inches are used more than feet in measuring, and dimensions are usually in inches, except for large work. In some shops they are given in inches even up to 10 feet.

Indicating Finished Surfaces

A drawing is or should be so marked as to tell the workman what surfaces are to be finished and what kind of finish is desired. This is often done by writing a character, resembling the letter *f*, across the line representing the edge of the surface to be finished, as in Fig. 22. Another way is to write the words "polish," "finish," "ream," etc., near the edges of the surfaces to receive the treatment indicated. Still another method that is much in use is to draw a red line near the edge of each surface to be finished. When a blue-print is taken from such a tracing, the red lines will print fainter than the black lines, and a draftsman can easily trace over them on the blue-prints with red ink. Still another method that can be used to advantage in a manufacturing plant is to put only the dimensions of finished surfaces on the drawing, leaving off entirely all dimensions of rough surfaces that are of service to the patternmaker, but to no one else. The workman in the shop then knows that wherever he sees a dimension the surfaces are to be machined. One feature that should be looked after more carefully than is usually done is to indicate how closely the various parts must be finished to size. If a piece must be made within a half-thousandth of an inch the workman ought to know it, and if a thirty-second of an inch is near enough he surely ought to know it. The practice of giving dimensions in thousandths of an inch where needed and of using plus and minus limits where sizes are to be kept within limits, putting the limits on the drawing, is a good one to follow.

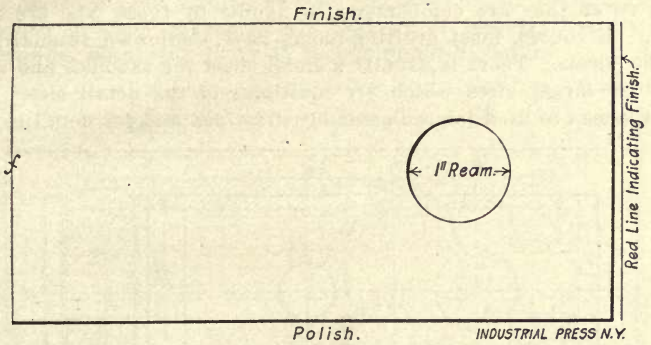


Fig. 22. Methods of Indicating Finished Surfaces

CHAPTER II

SIZES OF WORKING DRAWINGS*

Manufacturers do not have any universal standard of sizes for working drawings. From time to time there have been recommendations made by various societies regarding standard sizes, but these recommendations have had little effect in bringing about any generally accepted standard in drafting-room practice. Many firms use large and unwieldy drawings, which are as difficult for the draftsmen to work on as they are cumbersome to handle by those who are to use them. Of course, most drafting-rooms have their own standard sizes for the sheets. There is usually a small sheet for sketches and details and then larger sizes which are multiples of the detail size. These larger sizes are used for the assembly drawings and for detailing large

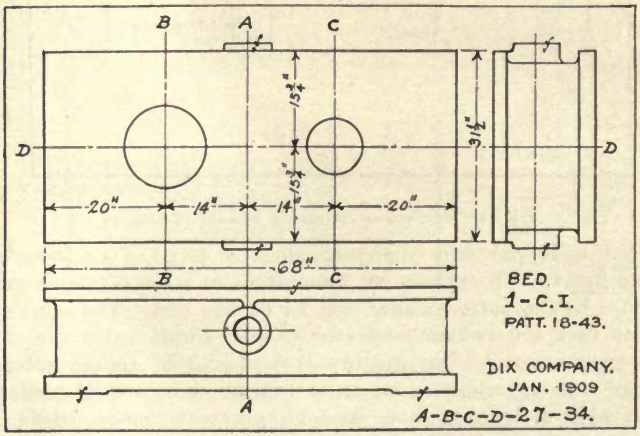


Fig. 23. Master Drawing of Simple Machine Bed

pieces. It is, however, difficult to take care of all these various sizes of drawings, a difficulty which can be avoided by having only one size sheet, of a convenient size for both the draftsmen and the shop.

The size of the sheet to be adopted should be chosen first of all with regard to economy in cutting the sheets from commercial sizes of paper and tracing cloth. Tracing cloth comes in rolls 30, 36, 42, or 48 inches wide, and there is thus a wide range to choose from. The standard sheet used by the U. S. Navy department, and, the writer believes, also by other departments of the government, is 21 by 27 inches.

All manufacturers working on orders for the Navy must send tracings of their work on this size sheet, and some manufacturers, therefore, have adopted this size as their own standard. It can be cut with-

* MACHINERY, March, 1909.

out waste from a roll 42 inches wide, but it is, however, too large to be convenient for the draftsman, as it makes his work much more tiresome than a small sheet where all corners can be readily reached from one position. Besides, this sheet gives more room than is necessary for detailing one piece of ordinary size, and therefore, as many as twenty pieces are often detailed on one sheet. This is an inconvenient system, as it often happens in the shop that two or more men must refer to different details on the same drawing, and often the blue-print will be cut in pieces so that each man gets the part on which he is working. This is a common-sense way of avoiding the inconvenience of having two men working on the same blue-print, and also is a hint to the drafting-room to have but one detail on each sheet. A convenient size sheet could be obtained by cutting the size mentioned in two, making a size 13½ by 21 inches. Even a somewhat smaller sheet, say 12 by 18 inches would be better.

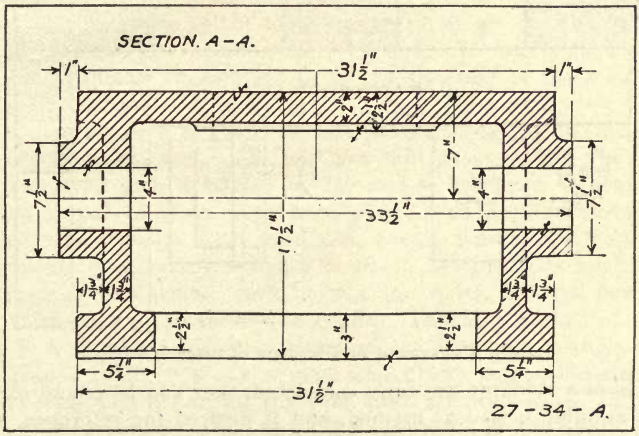


Fig. 24. Detail Section of Bed in Fig. 23

To use a small size sheet for all assembly drawings and for detailing of large pieces, requires a method somewhat different from those ordinarily in use in drafting-rooms, but it does not add to the complication of the work of the drafting-room. Fig. 23 shows a 13½ by 21-inch sheet, and on it is drawn a bed of simple design. The bed is drawn only in outline, and shows a plan, elevation and end view. The main center lines are also drawn, as well as the main faces. The drawing is numbered according to the regular system of the drafting-room. The center lines are lettered *A-A*, *B-B*, *C-C*, *D-D*; *A* refers to a second sheet of the same size on which is drawn to a larger scale the section *A-A* of the bed. On this sheet are put all dimensions, notes and instructions necessary. In the same way sheets *B*, *C* and *D* are drawn until the bed is fully detailed. The master sheet, Fig. 23, has in the title corner the letters *A*, *B*, *C* and *D*, showing at a glance how many sheets there are in the complete set. The next piece in the construction would be detailed in a similar way, the master sheet taking the

number 27-35, and having as many supplementary sheets, *A*, *B* and *C*, as necessary.

In case there is room on one sheet for more than one detailed section, these sections will be noted on the master drawing by the letters *A-A*, *A-B*, *A-C*, etc., the letter *A* being used for each section on sheet *A*. If the piece to be detailed is too large or complicated to have the three views clearly outlined on the master sheet, then each view will be made on a separate sheet, and the plan view will be considered the master drawing; the other master drawings have the same serial number, with a number added, as for instance, 27-34-1, and 27-34-2. In this way every part of the machine will be fully shown, as well in its relation to the other parts as in detail. In fact, the main purpose of the master drawing is to show the relation of the different parts of the machine to each other. When the master and detail

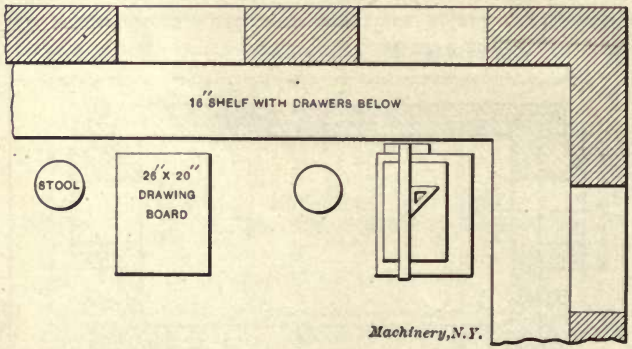


Fig. 25. Convenient Arrangement of Drafting-room

drawings of a machine are fully completed, they can be bound together by any suitable loose-leaf method, and if desired for reference, an index of the pieces can be made on a standard sheet.

Fig. 25 shows a convenient arrangement of a part of a drafting-room, where the small sheet system has been adopted. The designing draftsman's board is not shown. He, of course, must have a board as large as is convenient for the actual designing work. Running around the room, and under the window sills, is a shelf 16 inches wide, with drawers under, large enough for the standard size drawing. The draftsman's tools and books can also be kept in drawers under the shelves. Being at the left hand of the draftsman, the shelf is a convenient place for reference drawings, books, etc.

The system outlined has been objected to on the ground that it is not advisable to have the various views on separate sheets; much time is lost finding the sheets required to show the detail complete; the draftsman's time is unnecessarily wasted, etc. This criticism is partly justified, and it would be impossible to recommend the system for all classes of work and all conditions. Each individual drafting-room must decide for itself whether the work peculiar to it could be advantageously handled in the manner described.

CHAPTER III

DRAFTSMEN'S TOOLS

The selection of the proper tools is one of the most difficult problems which meet the young draftsman. Few draftsmen agree fully as to what constitutes a complete set of tools, or about the best construction of the various appliances. It is also evident that the draftsman must be guided somewhat by the class of work he is doing. Certain tools which may be required by the work carried out by one designer may not be of any use to another. In general, however, the requirements are fairly similar, and in the following is given a specification of a complete set of tools purchased by an experienced draftsman, for his own use. Undoubtedly his judgment and experience may give some valuable suggestions as to the selection of the tools needed by any draftsman.

In the set referred to the three bow instruments are 3¼ inches long with center adjustment. The bow pen will draw perfect circles from less than 1/32 inch diameter to 3¾ inches diameter. There is one 3½-inch pencil compass with fixed pencil and needle points, and a 5½-inch pen compass with fixed pen, needle points, and hair spring adjustment. The pencil compass is small, because it is preferable to use trams for all pencil work beyond its limits, but the pen can be used to advantage in the 5½-inch size. The hair spring adjustment on it is a great convenience, although by no means necessary. The fixed points would not pay a man who draws only occasionally, but for the man who draws all the time they are well worth the cost of the extra instrument. The two ruling pens are 5 inches and 5½ inches long. The trams consist of a tubular German silver bar in three sections, held together by long slip joints, and will work to a radius of 50 inches. Both heads slide on the bar, being clamped in the desired position with thumbscrews, and the points are adjustable in either head. The delicate adjustment is of the swinging lever type, which is the only satisfactory one for trams. There are two divider points, pen, pencil and needle points and a knife for cutting out circles. The whole instrument is very stiff, light and of remarkably neat appearance, with a bar long enough for all ordinary work, but when a longer one is required, it is easily spliced with one of wood.

No two men agree about triangles, but most of them prefer the transparent ones, although they are invariably too thin for the best results. A good selection consists of a 16-inch, 30 and 60 degrees, a 10-inch, 30 and 60 degrees, and a 5-inch, 45 and 45 degrees, for all ordinary work. A set of scales, as shown in Fig. 26, is far superior to the ordinary triangular scale. This set comprises 7 scales, ¼, ¾, 1, 1½, 3, 6, 12 inches = 1 foot. The full size scale is not shown in the

cut. These scales are of the reverse bevel type, and both sides of each scale are graduated the same, but read from opposite ends. With this arrangement it is never necessary to more than turn the scale over to have it reading in the desired direction. The divided foot on the 1½- and 3-inch scales is marked 2-4-6, etc., instead of the usual 3-6-9, which makes it easier to find the desired point. The 6-inch scale is fully divided into 16ths and the 12-inch into 32ds. Scales of this kind,

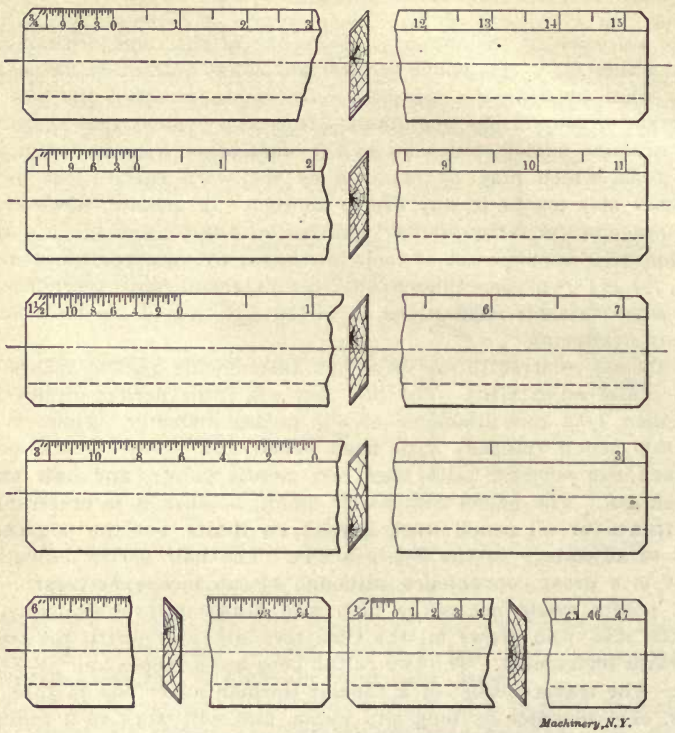


Fig. 26. Set of Draftsman's Scales

however, are made only to order by the firms manufacturing draftsman's scales.

A slide rule, a protractor, and a couple of curves complete the set of tools.

Special Draftsmen's Tools

While the set of tools described above is an excellent collection for general requirements, many draftsmen need special tools for special purposes. In the remaining portion of this chapter, a number of different tools and also a number of general drafting-room conveniences and devices are described, which will be found useful for the purposes for which they are intended. The descriptions of these tools have been contributed from time to time to the columns of MACHINERY, and the names of the contributors, together with the month and year

when the description was first published, will be found in notes at the foot of the pages.

Border Line Pen

The line cut, Fig. 27, and the half-tone, Fig. 28, illustrate a very efficient arrangement for a border line pen. It is made by taking a ruling pen, preferably one unfitted for further use, and fitting a piece

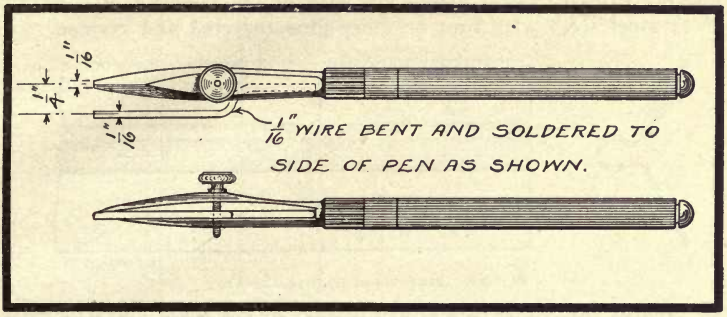


Fig. 27. Border Line Pen

of steel or spring brass wire in the middle of the pen and soldering it to the fixed half of the pen; then both pen and wire are ground off until the point of the former equals the standard width of line required, say one-sixteenth inch. Then the points are smoothed on an oilstone, by holding the pen perpendicular. By having a pen of this

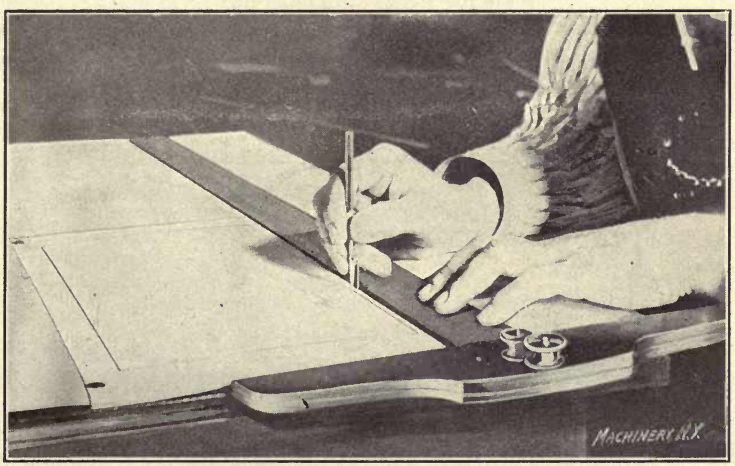


Fig. 28. Manner in which Border Line Pen is Held

kind in every drawing-room a uniform width of border line is fixed.

Fig. 23 shows the manner of holding the pen while using it; the pen is held perpendicular and with the wire against the T-square, which not only allows the draftsman to see what he is doing, but also prevents the ink from running under the edge of the T-square. The bor-

der around Fig. 27 was made by a border line pen of the description shown in the same figure.*

Attachment for Draftsman's Scale

Fig. 29 shows a very simple means of converting the ordinary draftsman's scale, graduated to 1/16 and 1/32 inch, as manufactured by the Brown & Sharpe Mfg. Co., into a scale that can be used for scaling or making drawings half size. The attachment consists of a narrow brass or steel strip with four or more pins inserted and riveted to it.

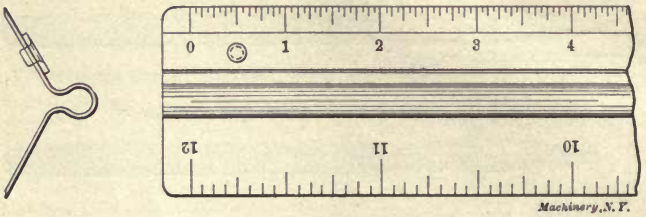


Fig. 29. Improvised Half-size Scale

These pins fit into holes which are drilled in the scale. A still better construction could be obtained by forming heads on the rivets, and having buttonhole slots in the scale. If it is desired to adapt the scale for half-size work, number each ½ inch consecutively as full inches. For quarter size, each ¼ inch should be consecutively numbered with whole numbers. Applied, as shown, on the 1/32-inch side, each graduation reads as 1/16 inch.

Scale for Beam Compass Bar

Beam compasses can be improved by placing a scale on the beam as shown in Fig. 30. A linen tape measure will answer the purpose.

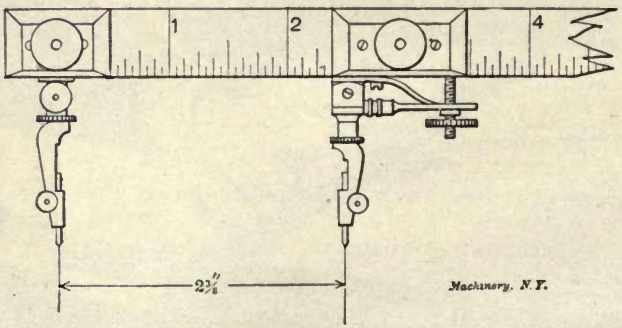


Fig. 30. Scale for Beam Compass Bar

A coat of shellac keeps it clean and the divisions distinct. The object of the graduations is simply to get the pencil point approximately set, the finer adjustment then being made.

Weighted T-square Head

The cut, Fig. 31, shows a T-square having a 1½-inch hole drilled in the upper part of the head, and a piece of steel inserted. The upper

* Albert C. Sharp July, 1906.

part of the head being the heaviest, it always tends to keep the upper edge of the blade down close to the board.*

Guide Strip for Drawing Board

A great many draftsmen are quite frequently troubled by lines drawn with a T-square not being parallel with each other at different points of the drawing board. This is invariably due to the fact that

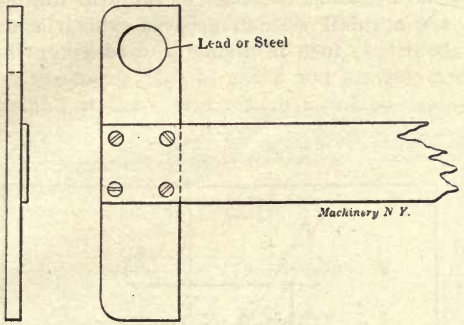


Fig. 31. T-square Head Weighted to Hold Down Upper Edge

the edge of the drawing board is seldom true. This trouble may be easily overcome by the application of the T-square guide shown in Fig. 32. The left-hand side of the drawing board is cut out 5/16 inch deep by 1⅝ inch wide, the full width of the board, and a bar of steel ⅜ inch by 1¾ inch, length to suit, is inserted; the latter is secured

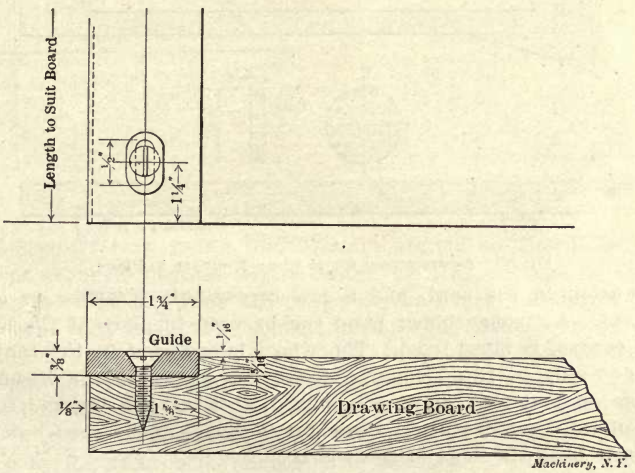


Fig. 32. Guide Strip for Drawing Board

by four screws, the holes for the screws being oblong to allow for any expansion or contraction of the drawing board. This guide, projecting ⅛ inch from the edge of the board, gives a smooth surface for the T-square head, and projecting 1/16 inch above the board, as shown,

* Gordon F. Monahan, August, 1906.

tends to keep the T-square blade just enough above the paper to keep the drawing paper, which is very often soiled by the shifting of the T-square, reasonably clean. Parallel lines at all points on the board are insured by the application of this guide.*

Arrangement for Holding T-square in Place

Fig. 33 shows a very simple, cheap and effective arrangement for holding the T-square against the edge of the drawing board. The materials needed are a small wooden grooved wheel, a sufficient length of heavy cord about 3/32 inch in diameter, a coiled spring to give suffi-

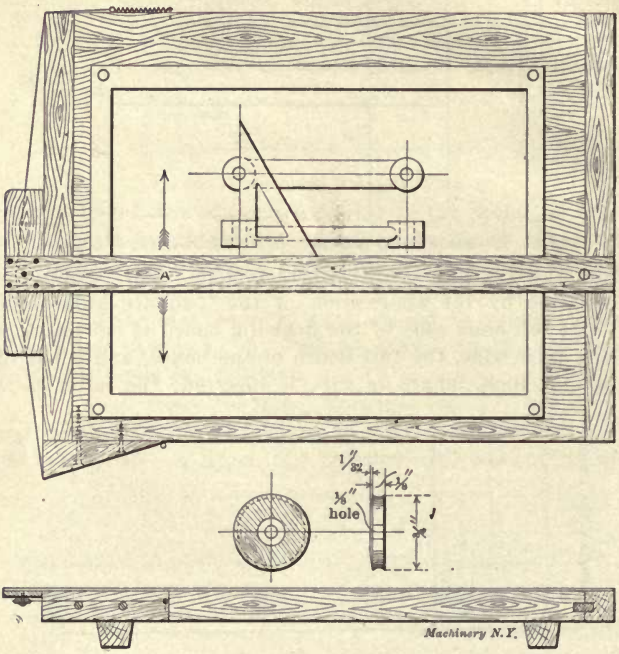


Fig. 33. Arrangement for Holding T-square in Place

cient tension to the cord, and a few screws, all arranged as shown in the cut. A strong rubber band can be used in place of the spring, but, of course, is short-lived. The wheel is fastened in the center of the under side of the T-square head. On small boards it may be advisable to fasten a small triangular block at the lower left-hand corner of the board so as to allow the T-square to be used when the drawing is near the edge of the board.

To one accustomed to the old method of moving the T-square by grasping the head and continually lining it up, the advantage of this simple device will be a surprise, as the T-square can be moved easily by applying the hand at *A*, about eight inches from the head, and when moved out of line it automatically returns to its proper place.

* J. C. Hassett, May, 1907.

An important advantage is, that in keeping the head snug against the edge of the board, the wear on the ends of the head where it slides on the board is avoided. This wear is caused on the ordinary T-square by the uneven pressure when sliding it up and down. The edge gradually becomes slightly curved, resulting in non-parallel lines on the drawing. Most draftsmen are not aware of this defect. The T-square is quickly detached by simply lifting it off the board, the cord slipping easily from the wheel. To find the proper tension for the cord, the T-square should be put in the center of the board, the cord fastened to the lower edge of board and brought around the wheel to a loop in the end of the spring which is fastened at the upper edge

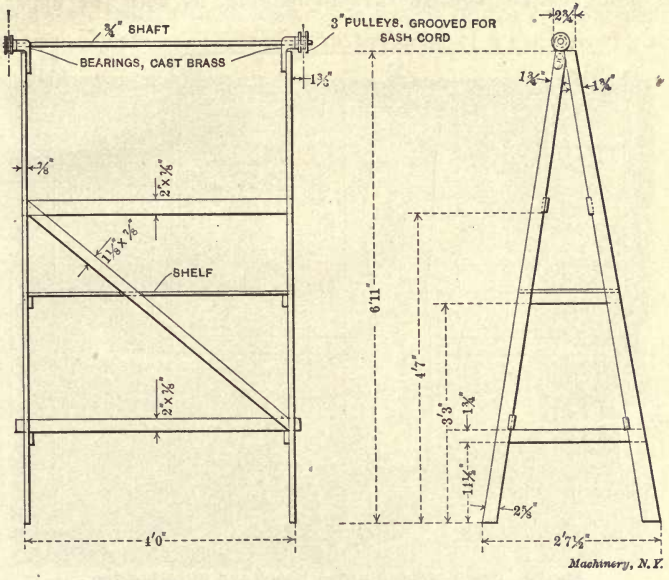


Fig. 34. Elevations of the Drawing Board Frame or Easel

of the board. Now swing the T-square around so that it lies at an angle of about 30 degrees to the center, keeping one end of the head against the edge and near the center of the board. Increase the tension on the cord until it is sufficient to cause the blade to swing quickly into place. In other words, it should be so tensioned that no matter in what position the T-square is left, it will immediately return to its proper position. This scheme can be applied to any common T-square up to 42 inches long, and, in fact, even to longer T-squares, provided a tension spring of proper dimensions is selected. Of course, it is preferable to use as light a T-square as possible. Note that the cord is not wound around the wheel, but simply bears on it exactly as trolley wire on a trolley wheel.

Large Compact Drawing Board

To meet the conditions requiring large capacity and minimum floor space, the board shown in Figs. 34 to 36 was built. The frame, or

easel, as artists would term it, is shown in Fig. 34. Only general dimensions are given, for such details as placing screws and making joints can be decided by the workman. The shaft, pulleys, and bearings, shown at the top, carry the counterweights needed to balance the drawing board. Fig. 35 shows the general dimensions of the board and straight-edge. The board is built of ⅞-inch stock in the usual manner, with a brace at each end and one in the middle. The end braces also act as guides, their centers coming in line with the center line of the pulleys on the shaft shown in Fig. 34. A 25-pound window-weight at each end serves as a counterbalance for the board which is thus easily raised or lowered.

The straight-edge requires care in making, as both the upper and

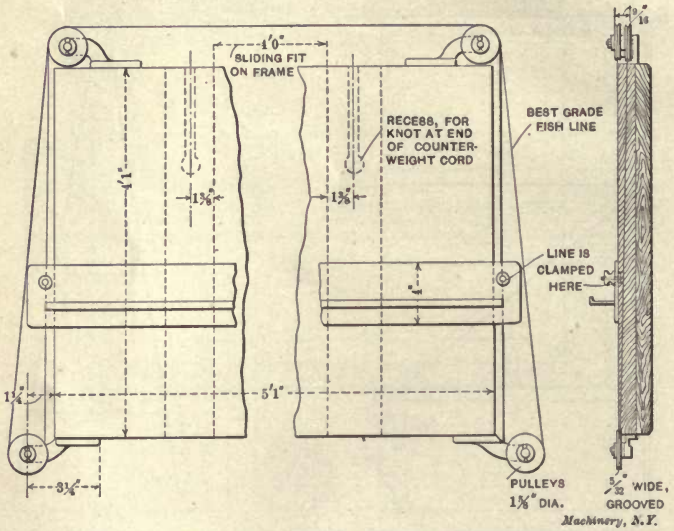


Fig. 35. Detail of the Drawing Board and Straight-edge

lower edges should be parallel. The projecting shelf is intended primarily as a brace, but it is also very handy for holding tools. By means of the line and small pulleys, shown in Figs. 35 and 36, the straight-edge is moved and kept in a parallel position at every point, the line being clamped at each end of the straight-edge by a brass screw and nut. The straight-edge is counterbalanced by a weight of cold-rolled steel hung from a cord attached just above the brass clamping nut.

The material used was as follows: 25 feet of pine, 15 feet of white wood, 2 pounds of brass used in the small pulleys and bearings, 53 pounds of cast iron in the drawing board counterweights and large pulleys, 4 pounds of cold-rolled steel 1 inch in diameter for the straight-edge counterweights, 7 pounds of cold-rolled steel ¾ inch in diameter for the shaft at the top of the frame, 25 feet of window cord, 35 feet of best quality fish line, and 3 dozen wood screws.

The time required to build this board depends, of course, on the skill of the workman. About 25 hours seems to be a good average time, a large part of which is spent in gluing the board. Foreign engineers say that this type of board is very generally used in Europe, and while at first sight a designer will usually disapprove of a vertical board, a few hours' trial will prove its merits.*

Draftsmen's Triangles

The triangle is such an important tool for the draftsman that it should be made as convenient as possible. The triangle shown in Fig. 37 is the result of a great deal of thought, and experimenting. The angles are 90, 75, 67½, 60, 45, 30, 22½, and 15 degrees, and each angle can be drawn from a light edge. The angles of the opening near the center are the same as the angles of the head of a countersunk screw.

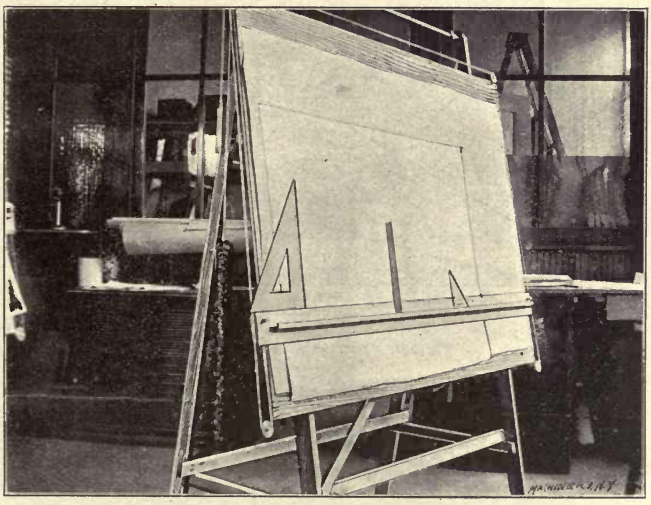


Fig. 36. Compact Drawing Board having Independent Vertical Adjustments for Board and Straight-edge

A 45-degree line scratched on the under side is very convenient, but great care must be used to have it accurate. This triangle has been made by a number of draftsmen, and all prefer it to the old 60- and 45-degree combination. It is particularly useful to the designing draftsman. It has, however, a disadvantage for inking, as a line drawn by a slot opening is liable to be blotted when the triangle is slipped along.

To make such a triangle, get a piece of celluloid 0.070 inch thick. Make a drawing of the triangle full size, and fasten the celluloid blank over it, so that the lines can be scratched as an aid to cutting. First, with a penknife start the openings, and, when large enough, use a hack-saw. Finish the edges with a file. After the slots have been worked out nearly to the finishing line it is a good plan to put the triangle away in a warm place for a couple of weeks, as it will shrink

* Ralph W. Davis, September, 1909.

so as to impair the accuracy of the angles. The dotted lines in the view to the right show how the celluloid will shrink. After the celluloid has finally set, very little care is required to keep the angles accurate.

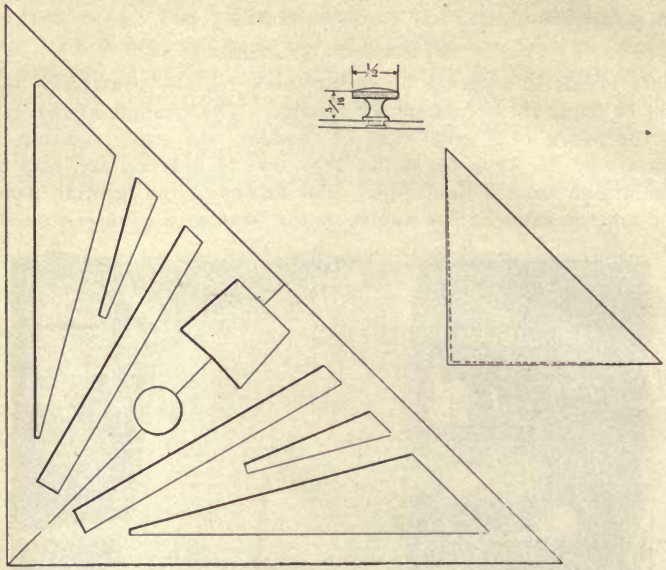


Fig. 37. Draftsman's Triangle

It is not necessary to tell a draftsman how to true up the outside edges. To true up the slot angles, the first thing to do is to draw a base line with the T-square. From this line lay off carefully all the angles that are on the triangle. With a file work out the slot edges

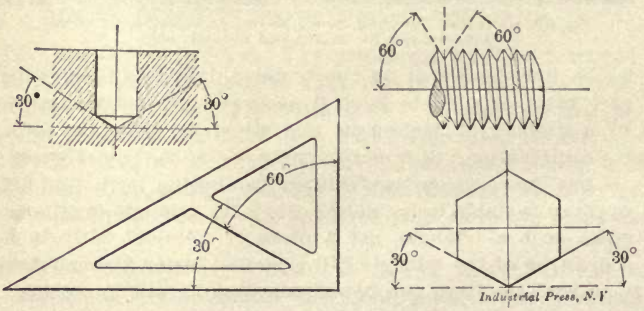


Fig. 38. A Handy Triangle

of the triangle so that, when laid against the T-square, the edges will match the drawn lines perfectly. Any waviness or inaccuracy is clearly shown by this method.

The knob should be riveted in, but do not hammer hard enough to

buckle the celluloid. The hollow side of the celluloid should be down, as the triangle will then lay flat.*

Fig. 38 shows another handy triangle of less elaborate design. It is a 30 by 60-degree triangle, having internal angles of the same degrees, but opposite to the external ones. With a triangle of this form hexagons, screw heads, the bottom of drilled holes, etc., can be easily and quickly drawn, as it is not necessary to reverse or turn over the tri-

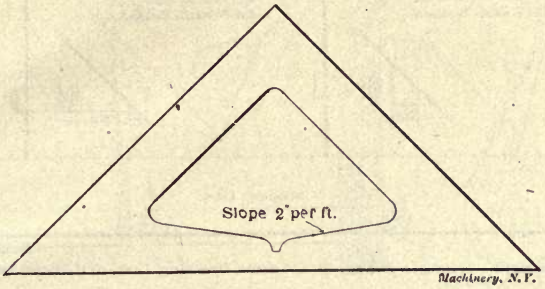
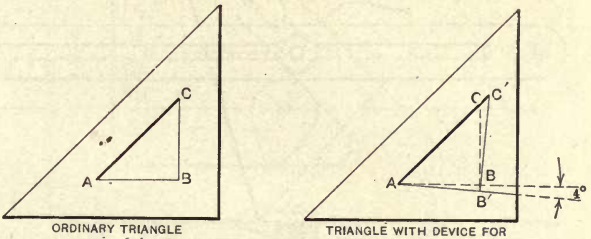


Fig. 39. Triangle for I-beam Sections

angle, but merely to slide it along. Every draftsman doing detail work will find this tool a valuable addition to his kit.

Triangle for Drawing I-beam Sections

Fig. 39 shows an alteration on an ordinary triangle which makes the drawing of the sections of I-beams and channels much easier than the usual way. The slant is that of the flanges of the standard rolled sections, i. e., 16 2/3 per cent or 2 inches per foot. This triangle is of



Figs. 40 and 41. Ordinary Triangle, and Triangle for Drawing Threads

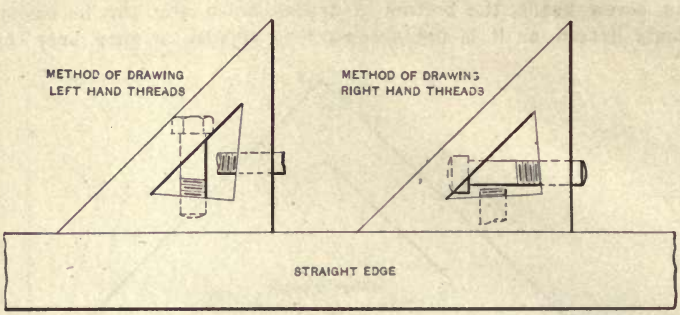
service to those draftsmen who have some structural work to do, but not enough to warrant the purchase of a special triangle.†

Triangle for Drawing Threads

Most draftsmen have more or less trouble in drawing the common representation of small screw threads. The cuts, Figs. 41, 42, and 43 show a simple device which makes this operation much easier, quicker, and not so tiresome. The threads also can be made more uniform.

* W. L. Breath, November, 1907.
† Roger Del. French, October, 1905.

Any draftsman can make this tool himself. Take an ordinary celluloid triangle, as shown in Fig. 40, a 45-degree triangle is preferable as the opening, *A B C*, in the center is larger, but a 60-degree triangle can be used. First draw lines on the triangle as represented by the lines *A B'* and *B' C'* in Fig. 41. These lines can be scribed on with any



Figs. 42 and 43. Triangle in Fig. 41 used for Drawing Left- and Right-hand Threads

sharp instrument, and should be at an angle of about 4 degrees with the horizontal. Now take a sharp knife and cut away the celluloid very carefully until having almost cut down to the lines. Then take a fine file and finish off to the lines, making the edges smooth and straight. Either horizontal or vertical threads may be drawn with-

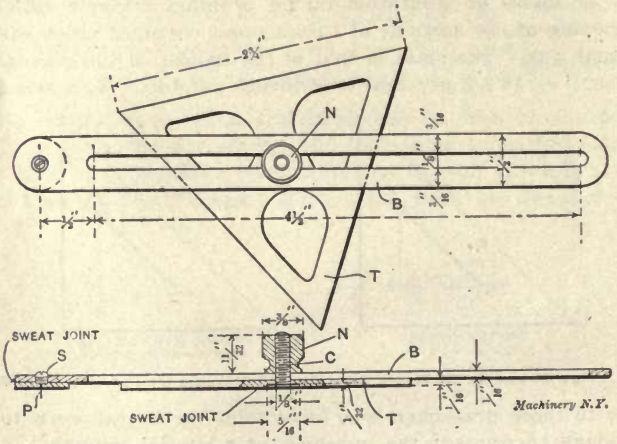


Fig. 44. Drafting Tool for Ratchet Teeth

out changing the position of the triangle, and right- or left-hand threads are drawn by simply turning it over.*

Tool for Laying Out Ratchet Teeth, Tangents, etc.

Fig. 44 shows a little instrument which is a great time-saver. It is used in putting in both radial lines and tangents about a given center,

* J. W. Coleman, August, 1906.

as in drawing the teeth of a ratchet wheel, etc. The slotted bar, *B*, has a pin, *P*, held in one end of it by the screw, *S*; this pin is stuck into the paper at the given center. The triangle, *T*, is shifted lengthwise on the bar and turned about the screw *C* until one of its sides

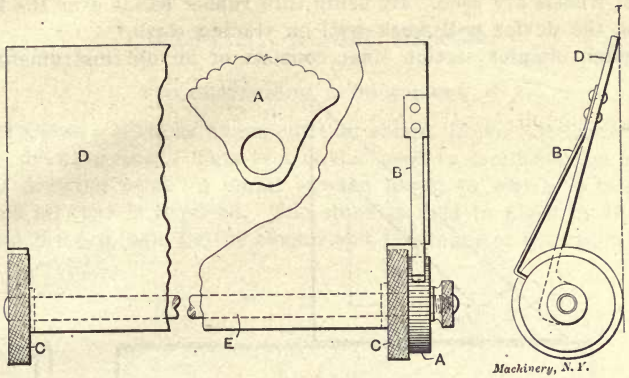


Fig. 45. Section Liner

takes the direction of the radial or tangent which it is desired to repeat about the center. The triangle is then clamped firmly in position on the bar by means of the knurled nut, *N*, and then, by swinging the entire instrument about the fixed pin, the edge of the triangle is brought to the successive positions at which it is desired to put in

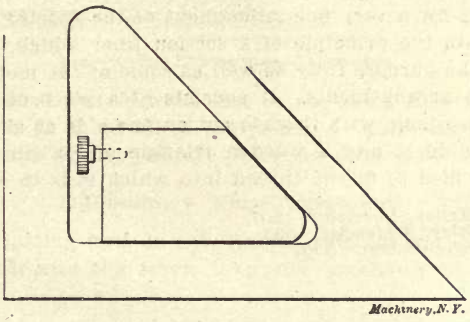


Fig. 46. Simple Section Liner

the required lines. The slotted bar, *B*, may be made longer than it is here shown, but, for nearly all ordinary drafting-room work, the length shown is sufficient.*

Section Liners

The device shown in Fig. 45 has given excellent results as a section liner. It is used on drawing paper entirely independent of a T-square. As seen from the cut, the device consists of a ratchet wheel *A*, a pawl spring *B*, two knurled rollers *C*, and the pen guide or ruler *D*. The teeth of the ratchet are milled as shown in the detailed view. The

* Claude T. Johnson, July, 1906.

ratchet and knurled rollers are fastened to the shaft *E*, and as the device is pulled back across the drawing paper for each line drawn, the ratchet pawl descends into each of the little grooves in the wheel, thus spacing the lines evenly. For different spacing, differently pitched ratchet wheels are used. By using thin rubber bands over the knurled rollers, the device will work well on tracing cloth.*

A much simpler section liner consists of an old instrument screw

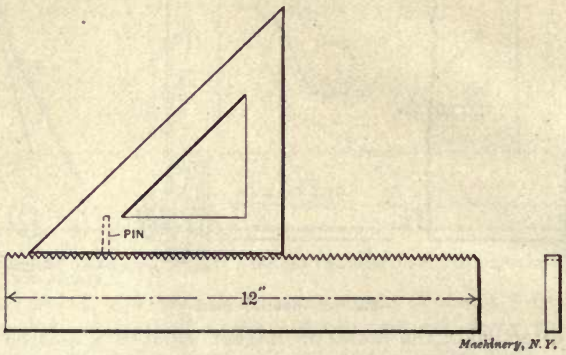


Fig. 47. A Simple but Efficient Section Liner

turned into a slightly smaller hole in a piece of wood a little thicker than the diameter of the screw-head, and of such size that the two can be used in the central hole in a triangle as shown in Fig. 46. The screw provides for a very fine adjustment of the spacing.†

Fig. 47 shows the principle of a section liner which, although simple, answers the purpose fully as well as some of the more complicated and expensive arrangements. It consists of a piece of brass, or any metal, 12 inches long, with threads cut on one side as shown, about 40 threads to the inch, and a wooden triangle and a pin driven in as indicated and filed to fit the thread into which it is to engage.‡

* Charles A. Kelley, November, 1907.
† E. W. Beardsley, September, 1905.
‡ John H. Craigie, January, 1907.

CHAPTER IV

DRAFTING-ROOM KINKS

Pen Sharpening Arrangement

Fig. 48 shows a little arrangement that should prove very convenient in every drawing-room. This is a device used to facilitate the sharpening of drawing pens. A small wooden block, to which is attached a back, is all that is required. The stone is held in place by the left hand, and the pen, held by the thumb and forefinger of the right hand,

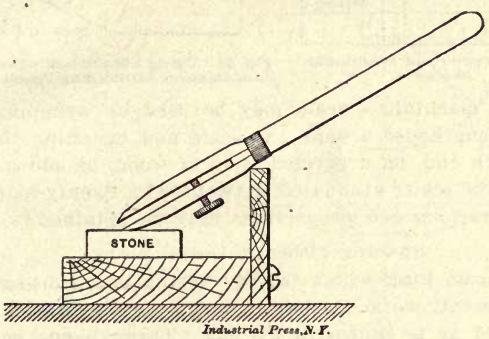


Fig. 48. Pen Sharpening Arrangement

is moved backward and forward and at the same time given a rocking motion so as to grind all of the point. In this way first one and then the other nib of the pen are given an ideal finish.

Tightening a Worn Thumb-nut

When the adjusting nuts on bow instruments become worn out, they can be squeezed onto the screw in a vise as shown in Fig. 49, and

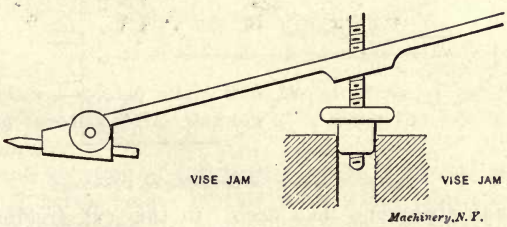


Fig. 49. Tightening a Thumb-nut

their useful life continued. This must be done very carefully or they will become too tight.*

* E. W. Beardsley, September, 1905.

Special Scales

A very convenient scale for one-half and one-quarter size work may be made by fastening strips of paper with shellac varnish just back of the graduations on a flat boxwood scale graduated full length with sixteenths on one edge and thirty-seconds on the other. On these strips the divisions are marked and lettered, making the scale divisions equal eighths on the proportional scale, as shown in Fig. 50.

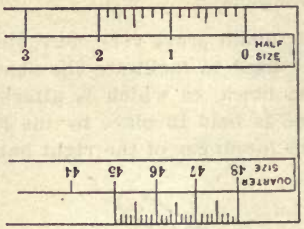


Fig. 50. Improvised Fractional Scales

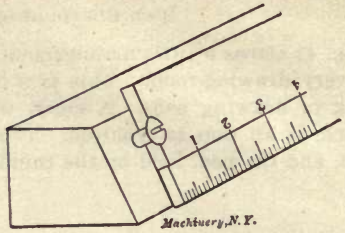
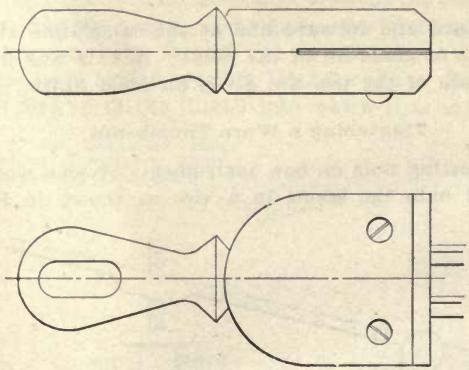


Fig. 51. Using a Machinist's Scale and Strips of Paper for Obtaining Fractional Scales

Similarly a machinist's scale may be used by wrapping a strip of heavy paper lengthwise around the scale and fastening the two, with a screw at each end, on a beveled strip of wood, as shown in Fig. 51. With machinists' scales graduated to twentieths, twenty-fourths, twenty-eighths, etc., various odd proportions may be obtained.*

Spacing Titles on Detail Work

A drafting-room kink which is very useful as a time-saver in spacing titles on detail work consists of a few needles and a small piece of wood turned as is shown in Fig. 52. Through one end a narrow



Tool for Spacing for Lettering on Drawings

saw cut is made about one inch deep. In this cut are inserted and spaced as many needles as are desired. The needles are bound in place by two round-head wood screws. The cut shows such a spacer set to mark for two lines of letters.†

* E. W. Beardsley, September, 1905.
† Raymond C. Williams, March, 1907.

Ink Bottle Holders

Ink bottle holders of various designs are constantly appearing in the technical press. In the following a number of the typical designs and suggestions are given, with a view of showing as many of the different designs as will satisfy all different requirements.

Fig. 53 shows a bracket holder, which is attached to the under side of the table by a single screw so that it may be swung around out of the way. This arrangement insures that the ink bottle is always in

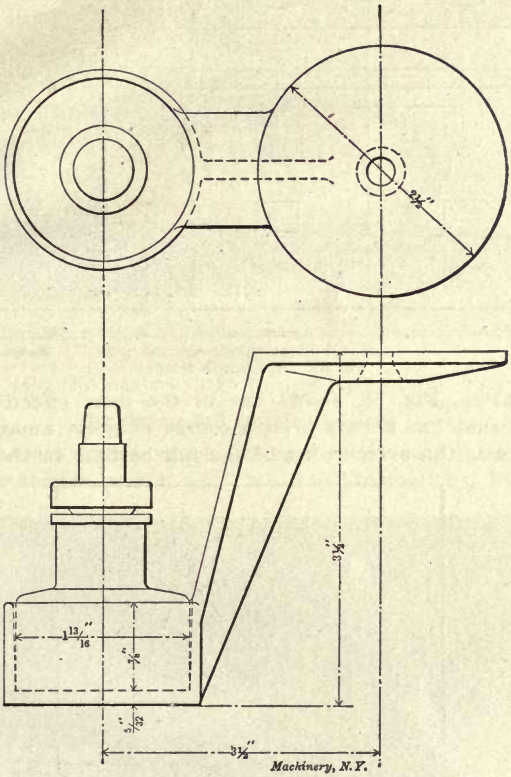


Fig. 53. Bracket-shaped Ink Bottle Holder

the right place; it also eliminates the liability of blotting the work when filling the pen. The danger of spilling the ink is also reduced to the minimum.*

A good and substantial ink bottle holder is shown in Fig. 54. To make an ink bottle holder of this description, take a block of wood about 3¾ x 7 inches and 1⅜ inch thick; have two holes bored in it part way, one at each end, to fit the ink bottles; also make a ½-inch hole for the quill; this will be found very convenient when lettering. Make a cup-shaped hole at a convenient place to put tacks into, and on one

* John Edgar, November, 1906.

side make a groove about ¾ inch wide to lay the lettering pens into; this completes the inkstand. It can be made at very small cost and presents a neat appearance.*

The greatest efficiency, however, often lies in the greatest simplicity.

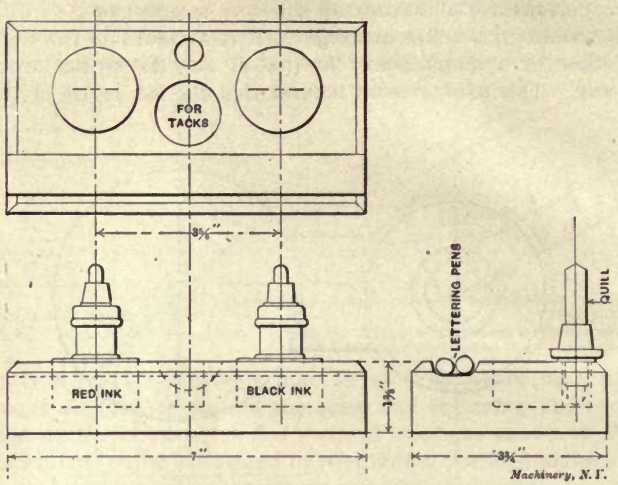


Fig. 54. Ink Bottle Holder

The illustration, Fig. 56, shows one of the most effective means of preventing what has always been a source of great annoyance to the draftsman, *viz.*, the overturning of the ink bottle. In the center of a

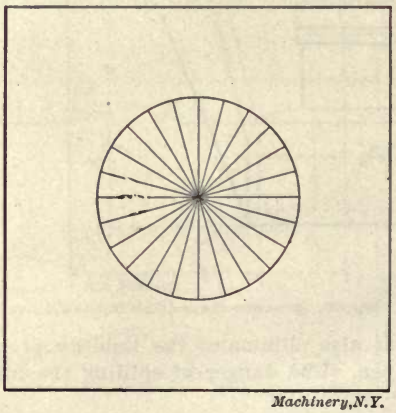


Fig. 55. Layout on Piece of Paper for Making Ink Bottle Holder in Fig. 56

four-inch square of ordinary drawing paper, scribe a circle equal to the diameter of the ink bottle. Divide the circle into about twenty-four parts as shown in Fig. 55, then, with a sharp knife, cut the paper from each of these twenty-four points to the center, following a radial line. Press the paper down over the neck of the bottle. Around the

* Peter Plantinga, February, 1907.

paper points, which stick up around the bottle like a picket fence, put six or eight ordinary elastic bands. Thumb tacks in opposite corners

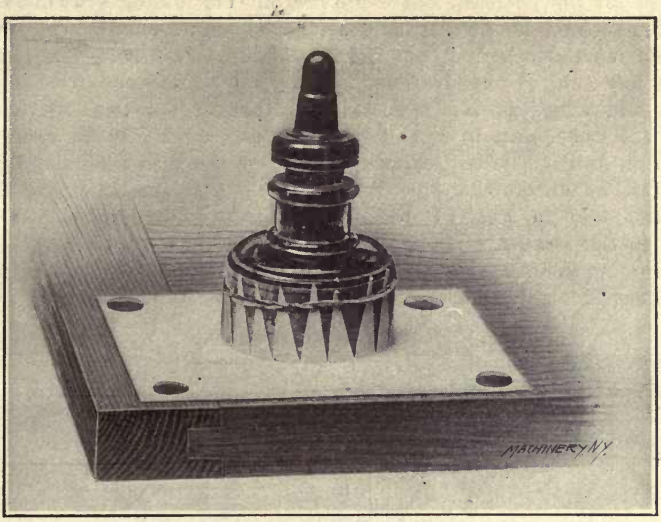


Fig. 56. Securing the Ink Bottle

will securely hold the entire outfit to any part of the board desired.*

Swinging Ink Bottle Holders

A more elaborate device, which has been found very satisfactory and convenient, is shown in Fig. 57. The line illustrations, Figs. 58 and

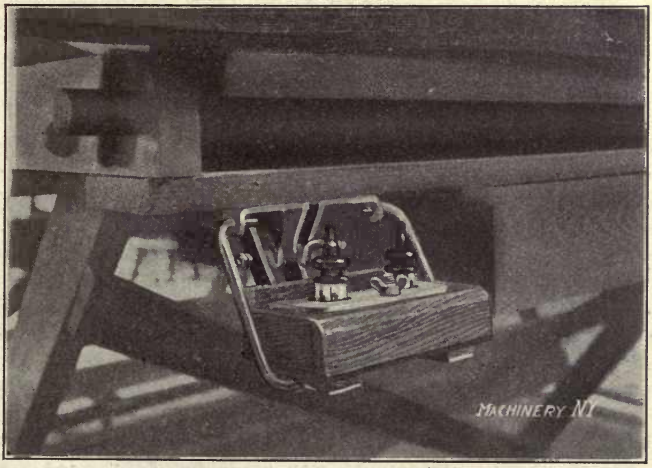


Fig. 57. Holder for Two Ink Bottles, which is easily swung out of the Way

59, show the construction with certain improvements over the original design shown in the half-tone.

* C. H. Ramsey, December, 1907.

The device illustrated may seem to have a great many parts, as compared, for instance, with a drawer, which is the first thing one would think of for the purpose; but a drawer on this folding drawing table would have been in the way, and a slide of ample length would have required more depth than was here available. This holder is located at the left side of the draftsman, and in the half-tone it is shown pulled out, affording ready access to either of the two ink bottles which are locked fast in it, and requiring one hand only for removing the filling quill. The bottles may be quickly removed for changing or renewing, by unscrewing the one thumb-nut and removing the brass retaining-plate in Fig. 57, the back edge of which slips into the recess in the wooden strip at the back. In the improved design this wooden strip is done away with, as is evident in the line drawing, ears being formed on the plates *B*, instead; also the thumb-nut and screw

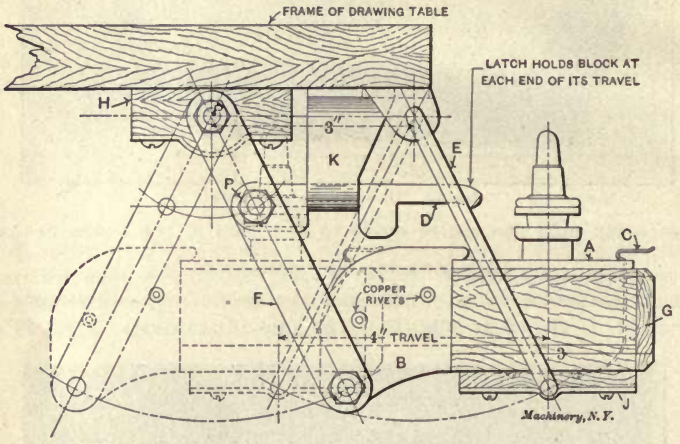


Fig. 58. Side Elevation of the Holder, showing the Inner and Outer Positions

have been superseded by a spring clip, *C*, making it still easier to remove the bottles.

After inking the pen, lifting the latch *D* with the tip of the finger enables the holder to be instantly pushed back out of the way; at the back end of the stroke the latch drops into place again and the swinging holder is retained there, entirely underneath the table and out of the way. The construction should be clear from the drawings, the marks or symbols used being the same in Figs. 58 and 59. The wooden parts of the holder are glued together, other fastening being afforded by the wood screws and the rivets indicated in the assembly drawing, Fig. 58. The portion of the drawing table to which the holder was attached is permanently horizontal, the drawing board, of variable slope, being pivoted above. Attachment was made by eight wood screws; of course, if desired it could be all attached to a separate block, permitting, in the event of shipment, removal without disassembling.*

* H. J. Kennedy, September, 1909.

To Prevent Lead Pencil from Breaking

A small shell partly filled with a piece of lead, steel, or shot, as shown in Fig. 60, and forced on the end of a drawing pencil, may

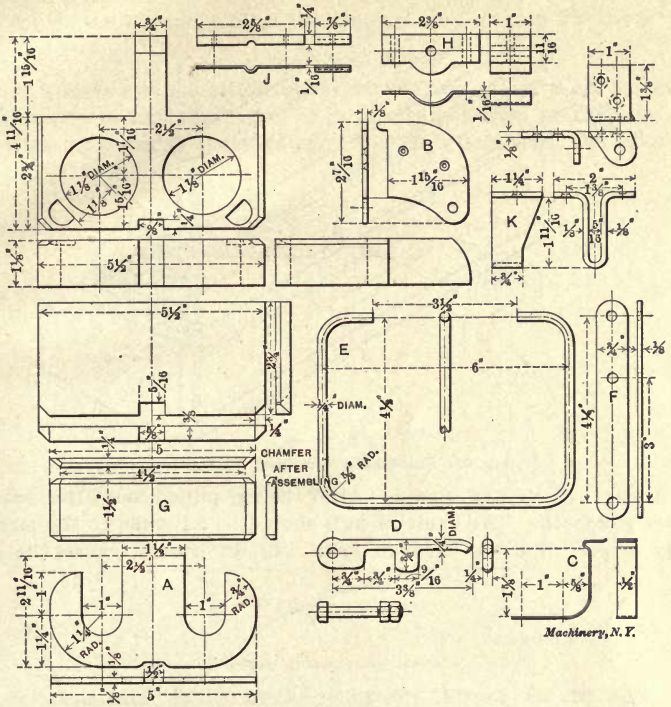


Fig. 59. Details of the Swinging Holder shown in Figs. 57 and 58

appear to be a queer contrivance; but this end being the heaviest will naturally fall to the floor first and will prevent the lead from breaking.*

To Remove Ink Lines from Tracings

Place the part of the tracing, containing the line to be erased, upon some hard substance, such as a celluloid triangle, and run over it lightly with a razor-edged knife; this leaves the cloth in rather a

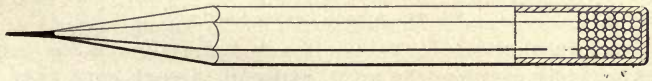


Fig. 60. Kink for Preventing Lead Pencil from Breaking

rough condition, which will be readily taken hold of by a medium hard eraser. The tracing may then be smoothed down by using the rounded edge of a knife handle or its equivalent, and will then take the ink without causing the latter to run.†

* Gordon F. Monahan, September, 1907.
† Calvin B. Ross, April, 1906.

Smoothing Wrinkled Blue-prints

Fig. 61 shows a method of "ironing" soiled or wrinkled blue-prints after they are dry. The wrinkled print is laid in a cabinet drawer with just enough of it outside to conveniently hold in the hands, and

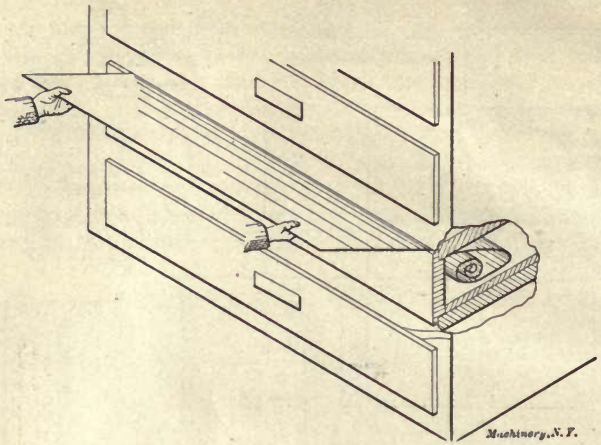


Fig. 61. Smoothing Wrinkled Blue-prints

the drawer is tightly closed. After being pulled out, the print is perfectly smooth. The angle of pull should be adjusted to the strength of the paper. Pulling through once will, of course, cause the print

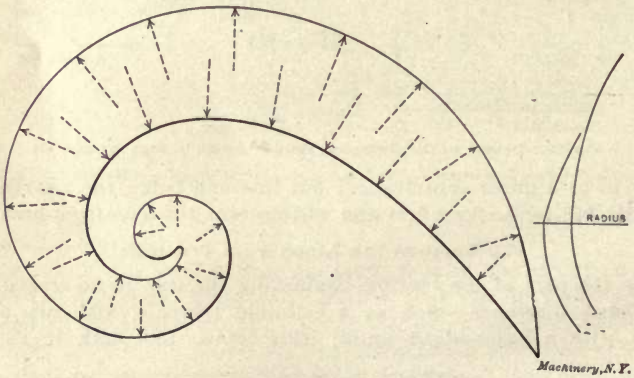


Fig. 62. Joining Curves Neatly

to roll up, when released; if this is not desirable, and the print is wanted to lie flat, reverse the print, and pull through once more.*

To Clean a Tracing

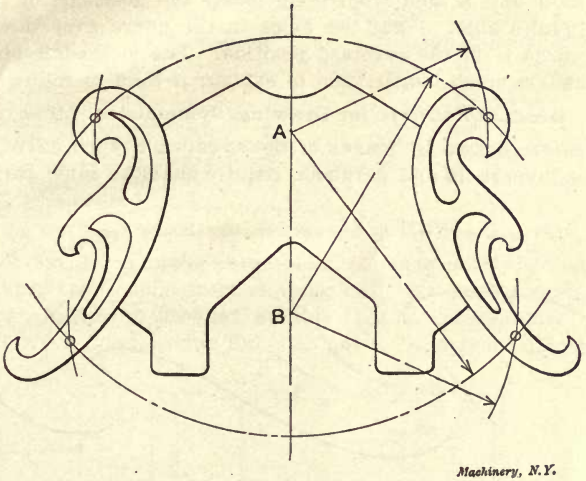
Tracings soon show the results of frequent use by becoming soiled, which, while causing them to look bad, at the same time makes it impossible to take good, nice, clear blue-prints from them. Oftentimes changes and corrections are "penciled in" on a tracing before inking

* Howard D. Yoder, October, 1907.

in. This leaves a confusion of penciled lines and figures. All this can be easily removed by lightly rubbing the soiled portions with a cloth which has first been saturated with benzine or gasoline. This, while cleaning the tracing thoroughly, will not effect the ink (provided waterproof ink is used), and makes the tracing look almost like new.*

Joining Curves Neatly

There is only one condition under which the end of a curve can be joined neatly to another curve, or to a straight line, so that the two lines shall flow neatly together—and that is where both the lines are



Machinery, N.Y.

Fig. 63. Drawing Symmetrical Reverse Curves

tangent to the same radius at the point of meeting. In any other case there will be a break or sharp place which will be very apparent to the eye; and further, a piece made after the drawing will not be so strong as though the curve flowed regularly. The difference in strength may be hardly calculable, but is there, all the same, and the appearance will always be better where this rule is followed.

There is a very simple way to attain this desired end, and that is to draw at various points on the wooden or other templets, which are used for making simple or compound non-circular curves, radii (or in the case of concave curves, prolongations of radii) to the curve, that is, lines at right angles to the curves at the points chosen. In Fig. 62 is shown a logarithmic spiral templet with such radii and prolonged radii marked thereon, together with (to the right) a compound curve drawn therewith without reference to the rule, and one properly drawn.†

To Draw Symmetrical Reverse Curves

In drawing a symmetrical figure which requires a right-hand and left-hand curved line, some difficulty may be experienced, especially if

* R. F. Kiefer, March, 1906.
† Robert Grimshaw, July, 1907.

a celluloid curve is used. By using a wooden curve, marks can be put on it to indicate the beginning and ending of the line desired, but doing this for some time puts the curve in a bad shape, and it becomes hard to discern which mark was put down last. It is hard to put marks on the rubber or celluloid curves, so the following method of using curves of any material seems to be far better.

As can be seen in Fig. 63, there is a hole about 1/16 inch diameter put in each end of the curve. In use, the curve is laid on the drawing, the location of the holes marked with a pencil point, and the desired curve drawn. On the center line of the piece to be drawn, select two centers, as *A* and *B*, and from them locate the positions of the holes in the opposite side. Place the holes in the curve over these points and the curve is in the reversed position. The method is simple; in fact, it takes a much longer time to explain it than to follow it.

Graduated Curve for Drawing Symmetrical Lines

Many curves drawn by means of the so-called French curve, such as the ellipse, hyperbola and parabola, require that the same parts of the

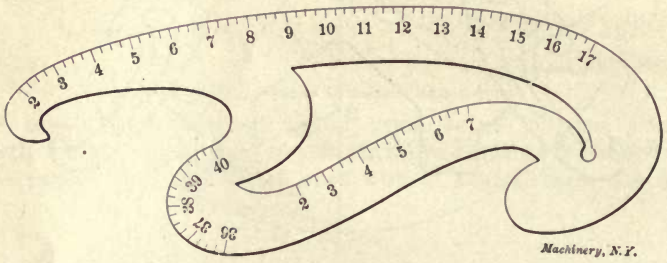


Fig. 64. Draftsman's Graduated Curve

French curve are used on each side of the axis of symmetry. The regularity of the curve and the degree of perfection of the symmetry will then depend on one's ability to reproduce in proper sequence on one side of the curve the parts of the curve used when previously drawing the other side. Fig. 64 shows a curve graduated on its edges with some arbitrary divisions, say in eighths. At every fourth one of these divisions a number is placed, starting with 1 at any convenient point on the curve and increasing by one until the graduations come back to the starting point. If the curve is made of celluloid the figures may be put on in black, so that when the curve is turned over with the figures down, they can be seen readily. If the curve is made of an opaque substance the numbers must be put on both sides. The numbers on the back should exactly coincide with the numbers on the face, and should proceed around the curve in the same order. In the cut the graduations are not shown all around the edges of the curve, but in graduating a curve they should, of course, be carried all around.

Attachment for Drawing Circles with Large Radii

In laying out work, it is often necessary to locate a center or some other point beyond the scope of the average-sized drafting-board. Fig.

65 illustrates a simple device that has been found to meet the requirements when such occasion arises. If the attachment is made according to the dimensions given, it will fit any board up to 1⅛ inch in thickness.*

Drafting-table Pencil-holder

The pencil-holder shown in Fig. 66 may be made of either wood, or aluminum. A very pretty effect is secured by making it of ½-inch strips of maple and cherry alternating. As an eight-degree tilt is a

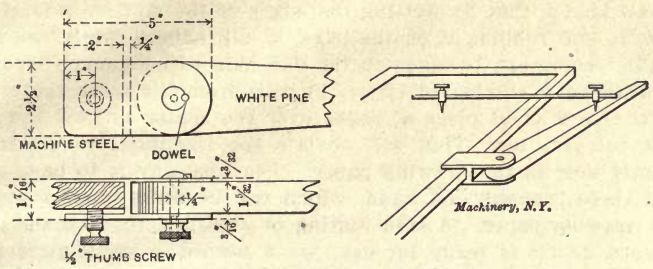


Fig. 65. A Handy Attachment for Drawing Circles with Large Radii

convenient one for a table, this holder is made with the same angle so as to keep the pencils from slipping out. By having sandpaper on the bottom, it can be used on a table that is considerably tilted by turning it around and having the cleat down. Nearly all draftsmen are

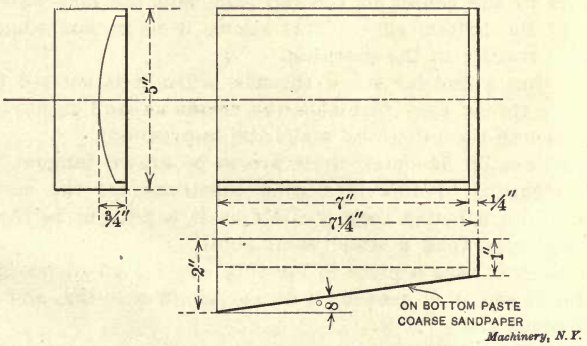


Fig. 66. A Drafting-table Pencil-holder

subject to annoyances arising from having their pencils and pens scattered all over the table; this holder, as can readily be seen, will remedy that.†

Restoring Over-exposed Blue-prints

Dissolve a quarter pound of potassium bi-chromate (a reddish crystal) in a gallon of water, and place the solution in a tray beside the wash tank. If a print is over-exposed or "burned," it is first placed in this solution and then washed in clear water; in this way a print

* W. L. Van Ness, June, 1909.
† E. G. Peterson, October, 1909.

is seldom lost because of over-exposure. It is, of course, possible to so burn a print that it cannot be bleached, but the ordinary burn of from two to ten times the required exposure, responds to the above treatment. The solution keeps indefinitely, if a few crystals and also water are occasionally added when required.*

Miscellaneous Hints for the Drafting-room

It is sometimes desired to make a tracing of cuts from catalogues, books, etc., and to do this without removing the page. Perhaps it is not well known that by wetting the edges of the starchy side of tracing cloth, and rubbing it on the page, it will adhere firmly enough so that the tracing can be made on the dull side without much trouble.

In drawing a number of circles or arcs from the same center it is best to glue a small piece of paper over the center to hold the point of the compass leg. This will obviate the likelihood of making an unsightly hole in the drawing paper. The best way is to have a supply of these "centers" on hand, which can be made from a piece of waste drawing paper. A thin coating of glue is spread on the paper, and when dry it is ready for use; when needed, a small piece is cut off, moistened, and fastened to the drawing paper. It can be easily removed from the sheet with the blade of a penknife, and the little glue which remains on the paper can be removed by the application of a rubber ink eraser.

It is a good plan when leaving a tracing on the board at night to remove all the tacks from the drawing and tracing except the one which is in the center of the top edge and the one which is in the center of the bottom edge. This allows it to go and come and to be tightened readily in the morning.

In spacing a line for screw threads, when it is desired to represent the V, the thread gage furnishes the means as well as anything could; simply choose the pitch and make the impressions.

When lines on an outer circle are to be drawn tangent to an inner circle, a cardboard disk is a good substitute for the eccentrolinead, and is as much better than a circle as is a pin put in the center for radiating lines, than a lead pencil point.

It is well to have a piece of blotting paper 2 x 3 inches hung on the wall, for, when it is needed, it is wanted in a hurry, and this makes a convenient place for it.

A small flat oil-can with screw top is very convenient to have among the draftsman's kit; if oil is used frequently on the screws and nuts of instruments they not only work better, but last much longer.

* Ralph W. Davis, October, 1909.

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